Electrical World and Engineer

THE CONSOLIDATION OF "THE ELECTRICAL WORLD" AND "ELECTRICAL ENGINEER."

VOL. XXXVII. NEW YORK, SATURDAY, JANUARY 5, 1901. No. 1.

PUBLISHED EVERY SATURDAY BY

ELECTRICAL WORLD AND ENGINEER

(INCORPORATED.)

120 LIBERTY STREET, NEW YORK.

TELEPHONE CALL: 4044 CORTLANDT. CABLE ADDRESS: ELECTRICAL, NEW YORK.

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ELECTRICAL WORLD AND ENGINEER.

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Change in advertisements intended for a particular issue should reach the office of the ELECTRICAL WORLD AND ENGINEER on or before MONDAY morning of the week of issue. New advertisements can be received up to 10 A. M. of Tuesday of the week of issue.

The first issue of each month is an export issue, having an extraordinarily large foreign circulation in addition to the regular domestic and foreign circulation of this paper.

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Entered as second-class mail matter at the New York Post Office.

NEW YORK, SATURDAY, JANUARY 5, 1901.

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THE FIRST ISSUE IN THE CENTURY.

With the beginning of a new year and a new century, the ELECTRICAL WORLD AND ENGINEER hopes to be pardoned for taking advantage of the present moment to say a few modest words for itself. The journal enters the twentieth century with a record of successful achievement dating back, in the case of one component journal, to 1874, and of the other to 1882, the commencement of the former thus antedating, and that of the latter being almost coincident with, the creation of the larger electrical industries which have shed so much lustre on the final years of the departing century, and which are yet very far from reaching a culmination. The new century finds the journal thoroughly organized for its work—the adequate treatment of every aspect of the science and industry which it represents. For the fullest attainment of this end, neither effort nor expense will be spared. The pens of the highest authorities in the various departments of electrical science are enlisted in the service of its readers; engineering questions will be covered by those intimately acquainted with the subjects involved, and the news of the day, scientific, professional, industrial and financial, will be reported in minute detail and at first hand in every possible instance. An acquaintance of a quarter-century's growth with the field and the men, gives every assurance of the world-wide collaboration neccessary to fulfill these promises.

To one part of the editorial policy of the journal particular attention is directed. The remarkable series of articles printed elsewhere in this issue on probable electrical developments during the twentieth century, forecasts many radical developments in electrical science that may be expected to occur in the near future, developments that will have a train of practical applications likely to revolutionize the industry. Judging from the history of the past, several new arts will be led up to by isolated discoveries or evolutionary processes, and he, therefore, who keeps step with current progress will be in a position of vantage to benefit from nascent opportunities before they become generally recognized. In order that its readers may enjoy such superior facilities of observation, it is the aim of the ELECTRICAL WORLD AND ENGINEER to keep them fully informed of every phase of electrical investigation, giving the earliest possible announcement of discoveries in electrical science and of advances in technical development, accompanied by comment pointing out their true significance and value, and followed where desirable, by articles from informed sources discussing every aspect of their bearing. In the future even more than the past, the prizes in the electrical field will be theirs who follow most closely the trend of development, and the pages of the ELECTRICAL WORLD AND ENGINEER will offer ideal means for keeping in the closest touch with every branch of current progress.

AT THE DOOR OF THE MAGICIAN.

The century just begun brings a message of promise and a hope of achievement that mean much to the race of men. Far be it from us to make light of its possibilities or to decry the prophets of gladness. Let the century past bury its dead—the only pity is that the bells that rang in the new could not in that hour have tolled the passing of much that the world regrets in the old.

But there is a lesson in the change that mankind would do well to heed—the simple lesson that time flows smoothly on with a current unbroken by the change of a date in the calendar. All that is hoped and predicted for men and their works in the next hundred years may come in the fullness of its time, but that time it may not be our

lot to see. Many things which seem near may be far away, and those that seem farthest may come before the new year is dead. The retrospect of the nineteenth century is glorious in progress of material things, but they came in their due season and with no hurried pace. The men who watched for the midnight stroke that sounded the beginning of the nineteenth century had for the most part gone to their rest before the first railroad train marked the commencement of a new era in transportation and the first telegraph key clicked its message of revolution. Fewer still were left when anesthetics first robbed the surgeon's knife of its terror, and even the little children who wakened at the summons of a hundred years ago were dim-eyed and feeble before those of them who were left saw the electric light and heard the earliest murmur of the telephone.

The epoch-making discoveries and inventions of the nineteenth century came slowly, many of them crowded into its last quarter. It took fifty years to establish firmly the mechanical theory of heat, more than half as long to bring to fruitfulness the germ theory of disease, and a decade to evolve the dynamo into practical usefulness. There is, therefore, no reason to expect that the present century will at once usher in profound changes in scientific doctrines or their commercial applications. However sure we may be of the great things to come, no man can tell the hour of their coming. Startling inventions may come and be developed to world-wide importance in a few years, as was the telephone, or the great result may be reached only by decades of patient building by many hands. It behooves one to be cautious in predicting, not great futures, but those immediately to be great. The glamour of the opening century is strong upon the world—it makes men prone to see visions and dream dreams. The next few years will be filled with the voices of would-be miracle-mongers, conjuring by the mighty name of the nineteenth century. Among them may be some new Archimedes, rushing naked from his bath with the frenzy of a great discovery upon his, but it will be hard at first to recognize him and to distinguish his voice among those of mere "barkers for the side-shows" of invention.

With all seriousness, science and invention are just at this particular epoch in a condition that makes the investigator and the inventor particularly liable to go off upon false scents, and it is going to take wonderfully fine discrimination to distinguish the false from the true. We may be upon the eve of tremendous generalizations and of brilliant discoveries, but it is a far cry to the conclusion that the next generalization will be tremendous or the next discovery brilliant. Scientific tolerance and cautious, painstaking investigation have never been more important than now. Many new things will come up in the next few years with the trademark of the new century upon them, and the mind must be trained to meet them and to examine them with swift precision for their right to bear it. Great inventions there will be, and great humbugs as well, and he will be keen-eyed indeed who shall not sometimes be deceived. The blue-glass cure and the telephone startled the world almost together twenty-five years since, but the one was taken and the other left. We shall see their like again, doubtless, and as many will be fooled by one as will have faith in the other. It is a fitting time for the wise to whet their wits.

Twenty-Five Great Names.

Elsewhere in this issue is printed the result of a vote by members of the American Institute of Electrical Engineers upon the twenty-five greatest names in electrical science and invention belonging to the century just closed. As the details of the balloting are given on the page opposite the printed lists, they need not be repeated here. It may be added, however, that additions to the vote from late budgets of ballots, as well as ballots received since the lists went to press, indicate a trend of opinion so remarkably regular that it is doubtful if even numerous additional votes would materially change the general list as printed. This view is further confirmed by the character of the two comparative lists, which were compiled to indicate the bias it was thought would be displayed by engineers toward the representatives of the industrial branch of electricity, and by teachers toward the theoretical branch. The result is somewhat surprising, for the lists on their face indicate, if anything, a tendency opposite to that which could reasonably have been expected; and no less surprising is the close resemblance of the two selected lists to each other and to the general list. It would be curious to know the result of similar balloting in Europe, and particularly as bearing on the extent to which, if any, selections made for the present lists were influenced by national bias.

From communications accompanying many of the ballots there was evidently, as might have been expected, considerable uncertainty as to the criteria to be applied in selecting names. Judging from these communications and from the character of the majority of individual lists, the criteria most often applied was that the work of those selected should be, first, of definitely intrinsic value and the result of high intellectual effort, as contrasted with achievements giving prominence to names merely from the owner's having been the first to seize a golden opportunity; second, that work conferring high distinction should be of a kind whose influence will extend through generations. In short, this implies taking the standpoint of one who endeavors to project his mind into the next century and predict its verdict. Others appeared to lay great stress upon mere priority of discovery, and others again to consider that great prominence at any epoch, however fugitive the prominence, is a claim for consideration.

While the lists undoubtedly reflect present opinion in electro-technical circles in this country as to whose names should be included in such a classification, it is needless to say that the verdict cannot be accepted as definite owing to the considerable number of names included of men yet living. Personality and lack of perspective are two factors apt to largely influence present judgment, and consequently, even if no other reason intervened, a discussion of the lists as a whole would not at the present time be opportune. Among the names of those, however, who have long passed away are two, the inclusion of which in the list may be challenged—those of Ohm and Oersted. So far as we have been able to discover by reference to authoritative sources, the only claim of Oersted to fame is the discovery of the connection between magnetism and electromagnetism, which consisted in observing that a magnet was deflected by current. This observation appears to have been entirely accidental, having been made one day during a class-room lecture. It is true that subsequently Oersted claimed to have predicted at the beginning of the century the relationship which his discovery established seventeen years later; but the work to which he refers is a metaphysical disquisition of the schoolmen type, which had no influence previous to 1820 and none after.

As to Ohm, the case is different from that of Oersted, for no one questions the great ability which he displayed in his mathematical investigation of the relation existing between current, resistance and electromotive force. This work, however, appears to have been, after all, merely a mathematical *tour de force,* for it proved nothing. Ohm's law expresses what must have been known by the earliest workers with electrical current, that an effect varies directly with the force producing it and inversely with the resistance encountered by the force. In his proof, Ohm, after laborious mathematical investigation, arrived at this axiomatic law, and his proof, though leading to correct results, was based upon a mistaken analogy between elec-

tricity and heat. The proof which Ohm's law requires and which was not given by Ohm, has not yet been offered. This consists in proving that the resistance remains constant for all values of current. As pointed out by Maxwell, Ohm's law must be considered a purely empirical one until this point is definitely settled. On the other hand, the law, as indicated by all experiments thus far made, is true within the limits of error of experiment. Assuming that this criticism of Ohm's work is well-founded, he nevertheless deserves some place in the roll of nineteenth century names of those who have influenced electrical advancement, through having introduced into the early science the definite idea of electrical resistance.

ELECTRICAL INDUSTRY.

When the old nineteenth century dawned there was no such thing in this world as an electrical industry, and all the great boons that electricity was to bestow on mankind were still to be created. We say "boons" advisedly and without emphasis, because Emile Zola inquires sceptically, What has the telephone, telegraph or electric light done to diminish the hunger of the hungry? Well, even if we conceded that they had done nothing toward filling anybody's stomach, we fail to see what difference that makes in a consideration of the subject, for, after all, we must look to the soil, the sea, the air, for food. Even if these "boons" had made no one happier, it would not be an argument for dropping them. Mankind in its onward march and its acquisition of new potentialities does not stop to ask whether plows or boats or tools make it happier, or whether they specifically fill its stomach. It welcomes all such new agencies because it has use for them and it never willingly lets one drop out of existence unless its utility is exhausted. The fact remains that we have these electrical inventions about which M. Zola groans so despairingly, and that they constitute no mean share of wealth and material comfort, besides making for happiness and sustenance. In spite of the fact that no one is in anywise compelled to use any of these latter day electrical appliances, their growing employment by the American public and the energy of American inventors and capitalists have created in less than a century values of over three billion dollars. The evidence as to the creation of such stupendous wealth of great earning power is given elsewhere in these pages, but it is apparent in every part of the country to one who will look around him.

The twentieth century begins with these electrical industries firmly established at home and reaching out for other spheres to occupy abroad. The export trade in manufactures, which was unknown a hundred years ago, has reached a total not far short now of $400,000,000 a year, and the amount is increasing. Of this value, a large part is electrical and mechanical, and the appreciation of American apparatus is really remarkable. No good reason can be found for doubting an expansion of this export trade, for while the growth of electrical industries has been enormous, it is the fact that the possibilities have been barely touched as the new century begins.

MEASURING THE RESISTANCE OF RAIL BONDS.

A convenient method of measuring the resistance of rail bonds is in terms of the equivalent length of continuous rail, and such a method has been practically in use in this country for at least ten years. A useful apparatus for enabling this to be carried out has recently been described in a foreign contemporary. A differential galvanometer is employed, and one of its two coils is connected across the bond to be tested, and the other across such a length of rail, in which the same current flows, that the deflection of the galvanometer is brought to zero. The method has the advantage that it does not require any electrical source to be supplied by the observer and operates by virtue of the electric currents always to be found circulating in the return circuit of a traction system. The practical difficulty is of course to obtain good contacts between the terminals of the galvanometer and the parts of the rail to be tested. Hardened steel points are generally employed for this purpose and with some pressure a fairly good contact can usually be secured with their aid. The wear and tear on such points in frequent service is, however, usually sufficient to require their resharpening at frequent intervals.

SYMBOLS FOR PHYSICAL QUANTITIES.

We publish in this issue a new edition of the table which we have previously printed, containing the revised symbols for units and physical quantities as recommended by the Committee on Notation of the International Electrical Congress of Chicago in 1893. Three new names are printed in Roman type in the column of units; namely. the barie, the gauss, and the maxwell, all of which have been adopted by the Paris Congresses of 1900. It is quite important that this table of symbols and units should be universally adopted by electrical writers, partly for the sake of convenience and ease in reading algebraic expressions written upon electrical engineering subjects, but principally for the sake of international uniformity of usage. It is, of course, quite impossible to maintain a symbol such as R exclusively for resistance in all branches of exact science—that would be displaying an exclusiveness unworthy of technology—but it is not too much to ask the specialists in electrical science and engineering practice to use this symbol for electrical resistance in preference to any other, because the conventional use of such a symbol means so great a simplification of the algebraic text.

Nothing is more important to clearness of thought and mutual understanding in electrical matters than a clear appreciation of the meaning and names of electrical units. Every electrical quantity requires a unit for the expression of its magnitude, and looseness of thought concerning the nature of these units and their relations to each other is apt to beget inaccuracy and misunderstanding.

The units in this table are defined according to the existing system of electro-magnetics. There is a discrepancy in the dimensional values of these units in terms of length, mass and time, owing to our ignorance of the nature of permeability and specific inductive capacity. Thus permeability is expressed as a mere numeric, whereby magnetizing force appears as the same kind of quantity as the magnetic induction which it produces. It is known that this cannot be correct and that the flux produced differs from the magnetizing cause or force as essentially as electric current intensity differs from electromotive intensity. In the absence of more precise knowledge, however, it is necessary to follow the conventions of existing text books, and the discrepancy is after all merely academic and is not likely to introduce any error in practical engineering work.

HIGH-TENSION ALTERNATORS.

It is a rough and ready rule for determining the pressure in kilovolts at which the most economical electric transmission of power can be carried, to take the distance of transmission in miles. Thus, for a distance of one mile 1000 volts is a common pressure, for 10 miles 10,000 volts, and 40 miles 40 kilovolts. There is, of course, no accurate basis for such a generalization, and no definite rule can be stated for determining the pressure, since the question is one of economics involving the cost of power, conductors, and also other factors in lesser degree. But as a rough approximation, the above rule is a useful one, when not carried too far. Thus it does not necessarily follow that to transmit power economically to a distance of 100 miles requires a pressure of 100 kilovolts. It might be accomplished at 50 kilovolts or even less. The effective range is, however, just as much determined by the pressure of transmission as the effective range of a projctile is determined, other things being equal, by the initial velocity of transmission. A premium is thus placed upon the pressure of generation in alternators designed for long-distance transmission.

If the pressure of, say, 50 kilovolts could as readily and safely be generated in an alternator as 50 volts, it would clearly save the use of step-up transformers at the transmitting end of the line. In practice, however, the difficulty of insulating high electric pressures renders it necessary to use less copper and more insulation in the armature as the pressure rises, until finally the output per pound of generator is seriously diminished, and the insertion of step-up transformers begins to be economical. This limit of direct high-pressure generation is, of course, a variable quantity, depending upon the type of alternator, skill in construction and other factors, but at present it seems to be placed at about 10 or 12 kilovolts. Below this pressure, direct generation can be secured in stationary armatures without too great a sacrifice of material. Above this pressure it is found necessary to use the step-up transformer, and when the step-up transformer is decided upon, the pressure of generation usually falls to about two kilovolts. This pressure does not require excessively heavy armature conductors, and is also convenient for short-range transmission.

THE DAWN OF THE TWENTIETH CENTURY.

It is fitting that on entering the twentieth century we mark the progress of electrical arts and sciences at so fitting an epoch in the progress of time. In this issue we have, therefore, devoted considerable space to a review of the past and to a consideration of the future so far as it lies within our power to prognosticate. The nineteenth century has been essentially the century of the engineer's success. Steam engineering, mechanical engineering and electrical engineering have made giant strides and have changed the faces of countries, the relative conditions of classes, and the mutual relations of nations. There is every reason to believe that the triumph of engineering in general, and electrical engineering in particular, will be yet greater in the time to come. Our electrical branch of the engineering industry is the youngest of all, but already has a great duty and power. It would be practically impossible for a country of the size of the United States to be kept intact and united without the electric telegraph and telephone. It would be practically impossible for cities to spread and grow without the ubiquitous electric trolley car. In all probability the applications of electricity to practical life will be more widespread and more marked in each succeeding year.

The only electrical directions in which the United States is notoriously backward, are, first, in a national laboratory for standardization, and, second, in submarine telegraph cables. In the electric transmission of power, in electric illumination and in electric lights, telegraphs and telephones, the United States leads the world in the magnitude of the work. But there are almost no American submarine telegraph cables, although there is considerable American capital invested in foreign submarine telegraphs. This deficiency is really due to the absence, until very recently, of American foreign possessions, and of an American merchant marine. Now, however, that American merchant shipping may be expected to develop rapidly, and also that American foreign possessions are found both in the Atlantic and in the Pacific, we may reasonably expect American submarine cables to come into existence.

As regards a National Standardizing Laboratory, England, France and Germany possess such institutions, the Germans leading the way. It is well known that German technical research has created for that country technical industries in which she takes a leading part, and there can be no doubt that technical industrial development in this country is being hampered to some extent by the absence of a standardizing bureau, through the work of which technical operations can be fostered and corrected. It is, therefore, greatly to be hoped that the Government of the United States will soon recognize the importance of such an institution and take steps to establish one, even if the commencement be but unpretentious.

PROBLEMS OF THE CENTURY.

The series of articles printed elsewhere in this issue under the general head of "Electricity in the New Century" forms probably the most important contribution of its kind ever made to periodical electrical literature. Every important department of the electrical field is represented in this series, with the single exception of the electric railway, the article on this subject having been unavoidably crowded out and will appear in the following issue. In general plan the articles include a résumé of development to date, a discussion of present status, and a forecast of future development. It will thus be seen that the series affords an admirable opportunity for readers who wish to start on the new century with a good general idea of the electrical status at the beginning, and to be informed concerning the developments to be reasonably expected.

Of the fifteen articles in this series, those of Professors Thomson, Trowbridge and Fessenden and Dr. Kennelly, deal more particularly with the great problems set for the twentieth century—electricity direct from carbon, light without heat, and developments in electrical theory. As concerns the first of these, a forecast cannot be considered very encouraging if based upon radical development along present lines. As pointed out by several of the writers, the only hopeful means of utilizing by electrical processes a larger amount of the energy of carbon than can be utilized in heat engines, lies in the direction of transferring the combustion energy of carbon to some substance capable of use in voltaic combination. This, it will be recognized, is a solution far from the ideal one. Looking into the immediate future, the best prospects for increased economy in the utilization of the energy of carbon appear to lie within the province of the heat engine, and Prof. Thurston in his article expresses sanguine views as to a considerable increase in economy likely soon to be secured from further perfections in the steam turbine and the gas engine. Still less hopeful are the views concerning the electrical production of light without heat. In fact, at the present moment it would appear that the solution of this great problem lies rather within the domain of the chemist than that of the electrician.

The very important fact should not be lost sight of, however, that a radical discovery comparable to those made by Faraday and Roentgen may instanter give a simple solution to problems which in the light of our present knowledge appear almost hopeless. By far the most promising path from which to expect such radical discoveries to appear—or at least from which to expect the clues upon which they will depend—is that leading from the laboratory and study of the electrical physicist. During the past several years the department of electrical theory has been the scene of an activity which, from its possible consequences, is comparable with that of the period of Faraday. Prof. J. J. Thomson and other workers have put forth hypotheses based upon physical investigation which not only threaten the entire fabric of established electrical theory, but from their radical nature give rise to hopes of most important consequences. The recent ideas, in fact, have led to the creation of a new branch of physical science—that of physical chemistry—dealing principally with electrical action in molecular and atomic phenomena. Should the mystery of the mechanism of these phenomena be discovered, it can reasonably be assumed that the problems of light without heat, and electricity direct from the combustible, will receive simultaneous solutions; and even a partial disclosure of the mystery of the hidden mechanism might be sufficient to this end. In the phenomena of electrical discharges in vacua, the physicist has been given a powerful means of approaching the study of molecular constitution, and it would be only a fair return if the solution of the several important electrical problems facing the new century were the first fruit.

The New Station of the New York Electric Vehicle Transportation Company—I.

By R. A. FLIESS.

THE Twentieth Century—the much heralded horseless age—is here and its advent has been happily commemorated in the City of New York by the opening of the new station of the Electric Vehicle Transportation Company, at Forty-ninth Street and Eighth Avenue.

It is probable that the opening, at this particular time, of the largest automobile operating, charging, storage and repair station yet constructed emphasizes more strongly than would otherwise be the case the remarkable progress that has taken place in methods of transportation on land during the century just closed.

When one recalls the fact that at the beginning of the nineteenth century the only practical method of transportation available on land for commercial or pleasure purposes was the lumbering stage coach or a horse's back, the wonderful advance that has been made in this branch of human industry alone during the short period of the last one hundred years is truly marvelous and causes speculation on the possibilities of the twentieth century to carry one irresistibly far into a field which to our great grandfathers would have been the realm of wonders.

In this connection it may not be uninteresting to note that it is just one hundred years since the first attempt to construct an automobile in America was made. To some this may appear surprising, but it is on record that one Oliver Evans—a mechanic, born at Newport, Delaware, in 1755—in the year 1801, started to build a horseless vehicle to operate on common roads. Owing to the inability of the inventor to find a single one of his contemporaries who was willing to speculate to the necessary extent in the experiments which he desired to make or even to lend him the benefit of moral support, he gave up his attempt to build his automobile, but not before he had made considerable progress towards the construction of a steam carriage designed to be driven by a non-condensing engine of his own design. This farsighted inventor predicted, however, at the time he gave up his attempt to construct a horseless carriage, that eventually vehicles would be propelled on common roads without the aid of horses, and that the time would come when people would travel in vehicles, moved by steam engines from one city to another, almost as fast as birds can fly. How fully this predicton, made just one hundred years ago, has been fulfilled, the thousands of miles of railroads and the rapidly increasing number of horseless vehicles now operating on our common roads bear eloquent testimony.

It was, however, only in the latter years of the last century that the great strides which have brought horseless vehicle locomotion on common roads to its present advanced stage of development, were made. Especially is this true in the case of electric vehicles, for it is only the developments that have taken place within the last twenty years that have made the electric automobile a commercial possibility. In fact, less than four years have elapsed since the first electric vehicle, built in this country to compete commercially with horse traction on common roads, was placed in operation. Since then the rapid strides that have been made in the development of this infant industry have been remarkable.

Perhaps, at the moment, no better idea of the magnitude of the development that has taken place in four short years can be obtained than is furnished by the brief history of the growth of the Electric Wagon and Carriage Company, from its small experimental beginning into the present Electric Vehicle Transportation Company, the new station of which has just been placed in operation.

HISTORICAL.

On the evening of Jan. 20, 1897, the American Institute of Electrical Engineers devoted its 112th meeting to a topical discussion on "Electrically Driven Vehicles," during the course of which it was stated that the Electric Carriage & Wagon Company was equipping a station in New York City, for the purpose of running a dozen or more electric carriages for public and private service. It was said at the time that at first the service would be more or less selective, as the impossible or impracticable was not to be attempted. It was also said that, as this station was the first of its kind that had probably ever been equipped, a number of new problems was constantly arising, and that it would be some months before it would be known, with any degree of accuracy, what the probable results would be. Looking back from our present point of vantage it would seem as though even the most sanguine of the promotors of that pioneer company could hardly have foreseen the rapid expansion which it was destined to ensue in such a short space of time.

In its issues of August 14 and 21, 1897, the *Electrical World* described the station of this company. The single room, 40x100 ft., which constituted its ground floor, was utilized as battery-charging room, vehicle-loading room, battery-switchboard room, washing room for vehicles and rental office, all in one.

The building, which was situated in Thirty-ninth Street, just west of Broadway, was a three-story one, and occupied a ground space of about 40x100 feet. Its total available floor space was 12,000 square feet, which, it may be interesting to note, is less than 10 per cent of that available in the Forty-ninth Street station. This pioneer station was equipped with 20 battery-charging stands, each of which would accommodate a battery of 44 cells. The new Forty-ninth Street station is equipped at present with charging racks enough to accommodate 640 batteries of 44 cells, and has been so planned and laid out that the battery-charging room can be extended in two directions, when desired, until it can be made to accommodate over 1000 batteries.

The rolling stock equipment of the Thirty-ninth Street station consisted of 12 hansom cabs and 1 brougham. The Forty-ninth Street station can accommodate 540 vehicles, with ample space left for their proper and easy manipulation, while over 700 vehicles could be crowded into the building, should the necessity arise. In fact, the Electric Vehicle Transportation Company expects to have the 300 vehicles, which make up its rolling stock equipment at present, in full operation in from thirty to sixty days, provided they can get enough competent drivers in that time.

Not long after the Electric Carriage & Wagon Company began to operate its pioneer station, it became evident that its Thirty-ninth Street quarters would soon become inadequate. In fact, in less than nine months after its first service had been inaugurated the company, which in the interim had changed its name to the Electric Vehicle Company, moved its station to a building, situated between Fifty-second and Fifty-third Streets, the main entrance to which was on Broadway. This building occupied a ground space of about 75x185 ft., of which part was given up to offices. A space, about 36x130 ft., was partitioned off as a battery-charging room, the ceiling of which was 11 ft. high. This room could accommodate some 200 battery-charging stands. The space above this room, some 4600 sq. ft., was used as a storage loft for vehicles. In the Forty-ninth Street station the battery-charging room occupies a floor space of 42x302 ft. and its ceiling is 20 ft. high. When enlarged to accommodate 1000 batteries, it will have a length of 474 ft. The storage room for vehicles in the new station is over 63,000 sq. ft.

As an indication of the growth of the business of the Electric Carriage & Wagon Company in its first months of business, the following data is interesting: During the month of March, 1897, the company had 8 vehicles in actual operation. No record was kept in this month of the number of calls received, but the number of passengers carried was estimated at about 300. Two more vehicles were placed in operation towards the end of the month. In April, 11 vehicles were kept in operation. The company received 280 calls for vehicles and carried 650 passengers, the 11 vehicles aggregating 1976 miles in that month. In May, 10 vehicles were kept in operation, 400 calls were received and 950 passengers were carried 2876 miles. In June, 11 vehicles were kept in operation, 632 calls were received, and 1580 passengers were carried 4603 miles. During the first year of its operation the vehicles of the company made a total of 45,833 miles, and as there were never more than 10 vehicles in actual operation on an average during the year, each vehicle must have made about 4500 miles during that time.

The result of the first few months of operation of the Electric Carriage & Wagon Company's station, as has been shown, was very encouraging, and doubtless prompted its removal to the Fifty-third Street station.

A very good description of the old Fifty-third Street station was published in the Sept. 3, 1898, issue of the *Electrical World*. In that issue it was stated that "the construction of the most elaborately equipped charging station for electric vehicles in the United States, and probably in the world, had just been completed in New York City." Yet in a little over three years it has been found necessary to abandon it for the new Forty-ninth Street station, which is so much superior to it in every respect. In fact, even before this last move was made the increase in the business of the Electric Vehicle Transportation Company—successor to the Electric Vehicle Company—had made an addition to the Fifty-third Street station necessary. So

some eighteen months ago a branch station was opened at Fiftieth Street and Eighth Avenue, in a building almost directly opposite the present Forty-ninth Street station.

The following table gives, it is thought, in a concise form, a very good idea of the remarkable growth and development that has taken place in the electric vehicle transportation field in New York City during the four years that have elapsed since the opening of the first commercial electric vehicle operating station.

TABLE I.

Year and Month in which Each Expansion Took Place.	Amount of Floor Space available in buildings Occupied as Operating Stations.	Approximate No. of Vehicles that Could Be Accommodated in Buildings.
March, 1897	12,000 square feet	25
November, 1897	24,700 square feet	100
July, 1899	71,812 square feet	200
December, 1900	128,600 square feet	700

From the table it can readily be seen that in the City of New York alone a great expansion has taken place. When it is remembered, however, that the above represents only one company and that there are now a number of electric vehicle transportation companies operating in several of our large cities, of which no account has been taken, the rapid growth of this infant industry is even more forcibly brought out and makes the prophecy, that the twentieth century will witness the elimination of the horse from commercial fields, if not its extinction as a species, seem less improbable than it otherwise would.

Perhaps no more appropriate illustration of the present tendency toward the substitution of mechanical traction for horse traction in all fields can be cited, at the moment, than is afforded by the opening of the new station of the Electric Vehicle Transportation Company.

Not many years ago the three-story brick building which occupies nearly two-thirds of the entire block, bounded by Eighth Avenue on the East, Ninth Avenue on the West, Forty-ninth Street on the South, and Fiftieth Street on the North, was used as a horse-car stable. To-day, however, its roof shelters only mechanically propelled vehicles. The building is divided in the center, nearly its entire length, by an open court into two halves. The northern half is used, at present, by the Metropolitan Street Railway Company as a car house for its Eighth Avenue electric surface cars. The southern half has recently been transformed by the Electric Vehicle Transportation Company, at a cost of over $175,000, from an old, dingy, odoriferous, and somewhat ramshackle horse car stable into a modern, clean, spacious and airy automobile operating, charging, storage and repair station, a description of which follows.

THE BUILDING.

As was noted above, the building is a three-story brick one, situated on the northwest corner of Forty-ninth Street and Eighth Avenue, and has a frontage on the avenue of one-half a block. It extends towards Ninth Avenue, on Forty-ninth Street, 475 ft. A plan of the ground floor of the building is shown in Fig. 1. It will be seen from an inspection of this that the first floor is divided into five sections. The section bordering on Eighth Avenue is used as an assembling, starting and turning room for vehicles that have been supplied with freshly charged batteries and that are otherwise ready to respond instantly to calls. In this part of the building, which occupies a floor space about 102 ft. square, is a commodious waiting room and starters' office and two stairways lead from different parts of it to the main offices.

Fastened to and ranged along the walls of this room are a number of charging sets, each charging plug fastened by suitable flexible connections to a rheostat placed on the wall. These are connected to the Edison three-wire system, which supplies power for the lighting and auxiliary motor service in the building. Though not intended for regular use they have been installed to provide against any contingency that may arise through which the main battery charging outfit is made inoperative, thereby, it is hoped, eliminating, as far as possible, the chance of a complete shutdown of the plant.

Situated directly behind the assembling room, and communicating with it by wide doorways, is the central portion of the building, some 300 ft. long, which is occupied by the vehicle loading, washing and inspection room; the battery-charging room; rotary sub-station room and battery assembling and repair room. In the rear of this section a space about 70 ft. long by 100 ft. wide is used as a charging room for pleasure vehicles. Part of this space is occupied by the boiler room and necessary appurtenances for heating the building.

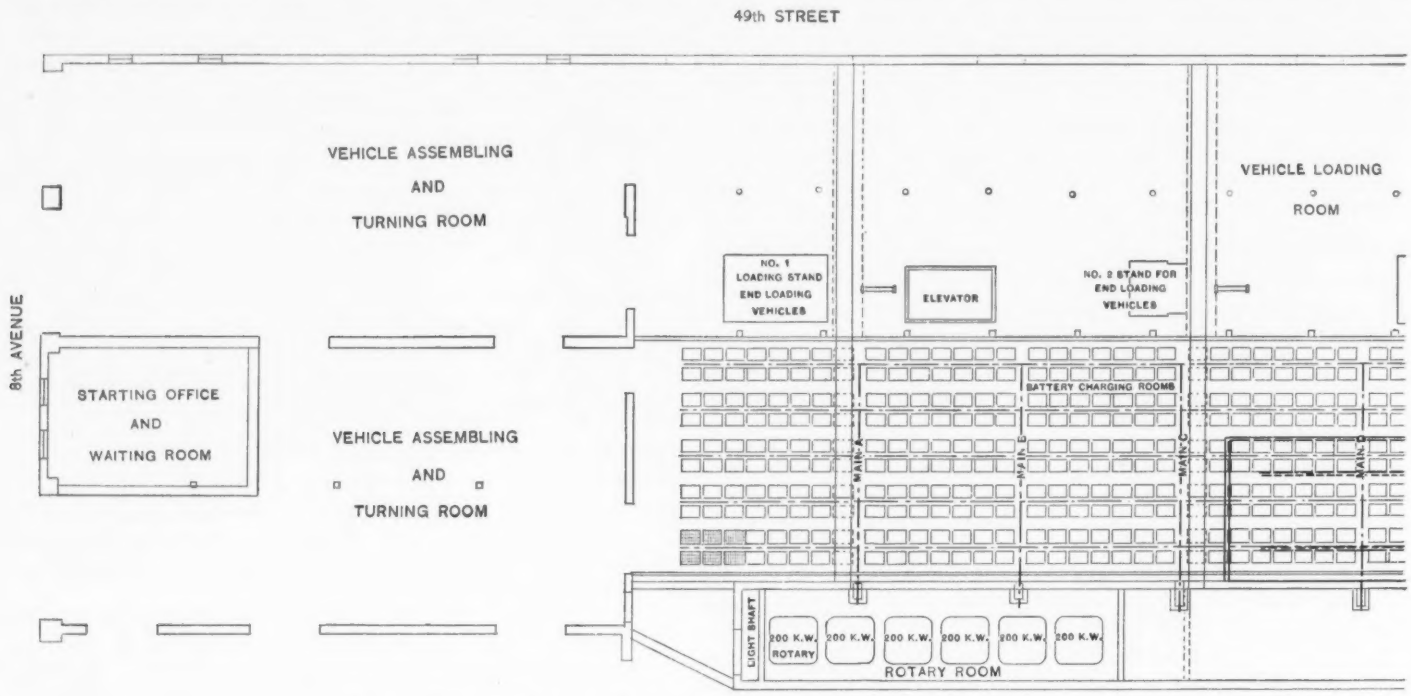


FIG. 1.—PLAN OF GROUND FLOOR OF STATION. (*See also page 7.*)

The second floor is divided into three sections. That facing on Eighth Avenue, a space about 102 ft. sq., is devoted to the main offices, store rooms, etc. The central section, 300 ft. long by 90 ft. wide, is used as a storage loft for vehicles for which there is no immediate call. This section is reached from the first floor by means of three electric carriage elevators and by several stairways placed, as may be seen in Fig. 1, in the vehicle loading room. On the northern side of this room, conveniently located with respect to the battery-charging room below it, is a room about 24 ft. wide by 88 ft. long, in which the battery room charging switchboard is located. The walls, ceiling and floor of this room are constructed of fireproof brick. The third section, a space about 70x100 ft., is used as a carriage body, repair and paint shop.

The third and top floor of the station, a loft some 400 ft. long by 90 ft. wide, is given up entirely to the storage of vehicles that are not needed or that are slightly out of repair, except a section at the west end, about 45x125 ft., reserved for a machine shop.

As the batteries are taken out of the vehicles before they are sent from the vehicle-loading room to the second or third floor, provision had to be made by which they could be operated other than by manual

power. To provide the required power, trolley lines were strung along the ceilings of the battery-loading room and second and third floor storage lofts to which flexible trolley connections are fastened by means of which power is supplied to operate the vehicles after their batteries have been removed.

From what has been said, it is thought, that a fair general idea can be obtained of the very extensive and elaborate scale on which the Electric Vehicle Transportation Company have laid out their new station. There are a number of interesting details, however, that have been incorporated in the construction of this station which will bear further description.

Probably the most important and vital part of an electric vehicle operating and charging station is its source of current supply. For on the regularity and constancy of this supply the success of the station mainly depends. Therefore, it is a consideration of the first importance, when designing a station for the operation of electric vehicles for commercial purposes, to make sure of a constant, regular and sufficient supply of current for the needs of the station.

THE CURRENT SUPPLY.

The current required to operate the station is obtained from the Edison Illuminating Company, of New York, which latter company has established a rotary sub-station in a section of the building occupied by the former.

The portion of the building in which the rotary sub-station has been established, as may be seen in Fig. 1, occupies a space about 16x65 ft. at the extreme eastern end of the open court, spoken of above, which has been roofed over and altered to accommodate the machinery required.

The present equipment of the sub-station is more or less a temporary one and will be added to or changed later as the necessity appears. At present there are installed four 200-kw General Electric 8-pole rotary converters. Space has been provided, however, for two more rotaries of the same size. These will be installed later.

Three-phase currents are delivered to the sub-station at 6300 volts and 25 cycles by means of a 250,000-cm three-conductor paper insulated cable. This cable has a capacity of 2500 kilowatts. An additional cable of the same size will be installed later as a reserve. The cable is brought to the rotary room through a conduit leading from the street and is carried to the second floor of the sub-station through a light shaft, seen in Fig. 1. A stairway leads to this floor from the western end of the room.

A high-tension switchboard is placed close to the eastern wall of the rotary room on the second floor. To this the high-tension cable is connected. On each of the two panels, which at present comprise the high-tension switchboard, are mounted the usual quick-break snap switches and fuse blocks. Also the terminals from the static transformers. Each high tension panel is connected to a set of three General Electric 145-kw air-cooled transformers mounted on a steel platform supported by the I-beams which hold up the second floor. This platform is airtight and is used as an air duct as well as a cable runway for the secondary connections of the transformers. A blower, directly connected to an electric motor, is mounted on the platform at its western end. This supplies the circulation of air.

The ratio of transformation is from 6300 volts to about 70. Each set of transformers feeds two rotaries. The two independent sets of secondary connections are fed in multiple from the same set of transformers, and each set is connected to an I. R. T. three-phase voltage regulator. Each regulator is capable of varying the impressed e. m. f. about 30 per cent. Three secondary alternating current connections pass from each regulator to a temporary switchboard situated on the first floor of the sub-station, as shown in Fig. 2. This board will eventually be placed on a raised platform at the western end of the room. On each A. C. panel is mounted a triple-pole single-throw 2000-ampere switch, a Thomson alternating current ammeter and receptacles for pilot and synchronizing lamps. Also the field rheostats for the rotaries. Cables are carried from the A. C. panels to the collector rings of the rotaries. From the D. C. end cables go to D. C. panels on the low-tension board. From here the cables are carried to an auxiliary regulating panel, on which arrangements have been made by means of several cross-connected switches, by which any

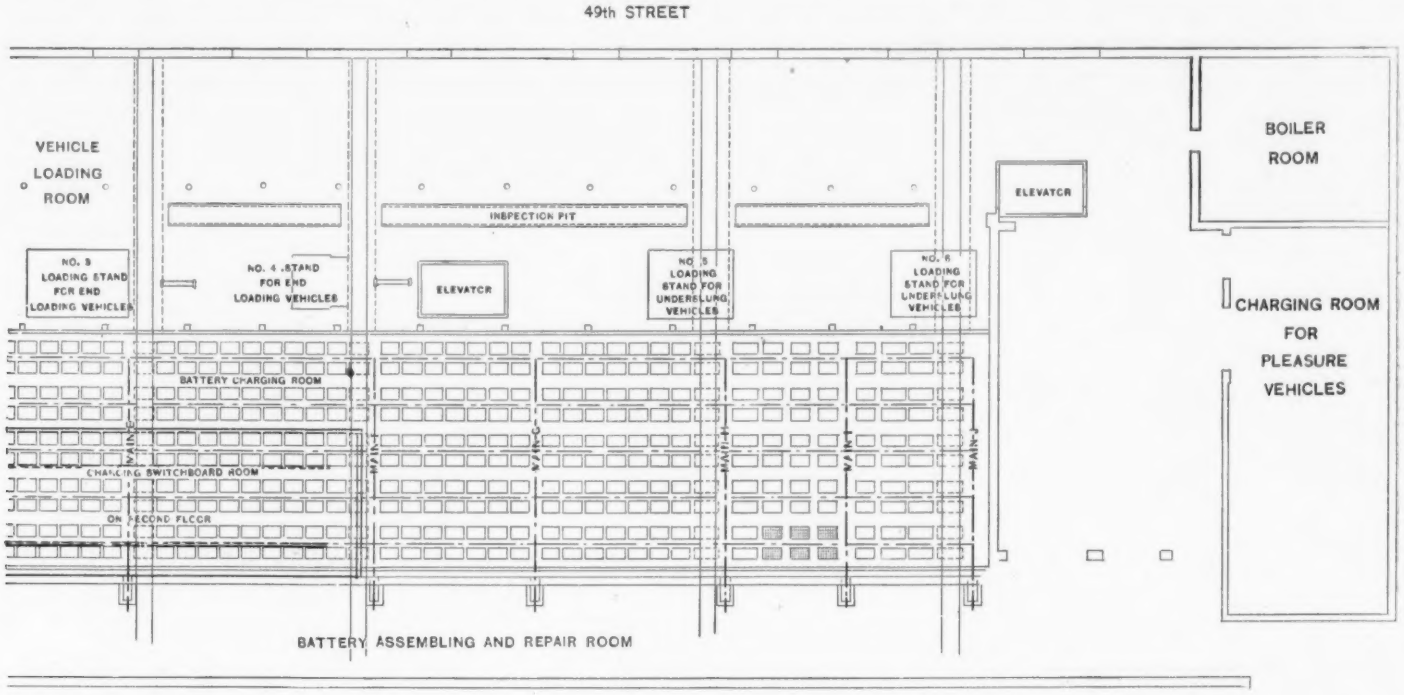


FIG. 1.—PLAN OF GROUND FLOOR OF STATION. (*See also page 6.*)

one of six bus-bars, placed in the battery switchboard room on the second floor, can either be connected directly to a D. C. machine panel on the low-tension board or through an auxiliary storage battery which boosts or crushes the voltage of the machine depending upon the way the battery is connected to the line. The present auxiliary battery equipment is four sets of three G 21 elements, each element placed in a lead-lined tank. The tanks have a capacity some 60 per cent greater than is required at present. The normal capacity of each element is 1600-ampere-hours, at a 200-ampere-hour rate, or it can give 400 amperes for 3 hours. By this arrangement a number of different voltages can be obtained in the battery-charging room without the use of rheostats, for each rotary can be regulated by its I. R. T.-voltage regulator to give a different pressure from that of any of the other machines, while by the use of part of the present auxiliary storage battery, as a booster battery and part as a crusher battery, four more variations, differing by about 6 volts, can be obtained. When the full equipment of six rotaries has been installed, it will be readily seen that by the use of a booster and crusher battery with each machine, 18 different bus-bar voltages can be obtained, if desired. With the present installation, 8 different voltages are possible. In fact, the 6 different bus-bar voltages, for which the battery switchboard is wired, can be obtained when any two of the rotaries are running by means of the auxiliary storage battery already in place. It will be seen that a very flexible system of variable potential current supply has thus been provided and that this has been accomplished without the use of a single rheostat, in which the $C^2 R$ loss is appreciable, even when the battery load is heavy. The — side of the

battery room charging circuit is tied together by means of common return cables and is brought to the direct-current panels on the low-tension board in the rotary room.

The 250,000-cm cable which carries the high-tension current from the central station to the rotary sub-station, is connected to the Thirty-ninth Street station of the Edison Illuminating Company through which it can be connected to any one of the other central stations operated by this company in New York City.

An independent supply of current for lighting the building and for operating the crane and other auxiliary motors is supplied directly from the mains of the low-tension three-wire system of the Edison Illuminating Company by a cable which enters the building through a conduit, which opens into the light shaft back of the rotary room.

The direct current, used to charge the batteries, and which, as has been noted, is obtained from the direct end of the rotaries, passes by means of a number of 1,000,000-cm cables from the low-tension switchboard to the battery-charging switchboard.

THE BATTERY-CHARGING SWITCHBOARD.

This board is laid out according to the floor plan of the battery-charging room. The board is made up of sections, formed of iron channels and Ts, on each one of which are ten charging panels, placed one above the other, as is shown in Fig. 3. Each panel represents a battery-charging stand, and is composed of slate, boiled in paraffin, on which is placed a double-throw double-pole switch, one side of which is connected directly to the battery-charging stand. The other side is connected to the battery-charging stand through an ammeter fastened to the top part of the section.

By this arrangement one ammeter is made to serve for ten batteries. Each switch is provided with two 100-ampere fuses, one in each of its two circuits. Just above the switch and connected to each side of it is a plug-switch arrangement, by means of which the battery rack can be connected to any one of the six bus-bars fastened to the back of the switchboard by the insertion of a metallic plug in the one of the six holes which represent the voltage desired. Fig. 4 shows the arrangement of the wiring and the position of the bus-bars back of the switchboard.

From the back of each panel a No. 6 wire extends to each bus-bar and one No. 6 wire is carried from each panel by means of suitably supported Alberine stone insulators to the battery room, where it is carried in channels in the floor to the battery-charging rack which the panel represents. The operation of this board is very simple. When a battery is placed on a charging rack its weight automatically connects it to the charging circuit. The switchboard attendant is notified that the battery has been placed on a certain rack and is ready to be charged by means of a little check, which has the number of the rack on it. This check hangs on the battery rack when no battery is on it. As soon as a battery is placed on the rack the check is sent up to the switchboard room by means of a small lift and the switchboard attendant takes it, goes to the panel, which is connected to that rack, sees that the plug is in the hole that represents the lowest bus-bar voltage, then closes the circuit through the ammeter. The reading on the ammeter shows him at a glance the condition the battery is in and experience tells him whether to leave the battery on charge on the low bus, whether to plug in a higher bus or take it off-charge altogether. Suppose a battery is in proper condition to be left on the low bus when first put on charge. As soon as the switchboard attendant has noted the current the battery is taking, he reverses the switch, thus cutting out the ammeter, which is then available for use with another battery. After a certain time the switch is again thrown, so that the ammeter reads. If the c. e. m. f. of the cell has risen sufficiently to cut down the current below the charging rate desired the plug is inserted in the hole which represents the next higher voltage. This process is continued until the current drops below a certain number of amperes, when the battery is connected to the bus-bar, which represents the highest voltage. The battery is then charged, in so far as the switchboard attendant is concerned, and he takes it off-charge and sends the little check back to the battery room man, who places it on the battery box. This indicates to the crane-man that the battery is ready to be placed in a vehicle.

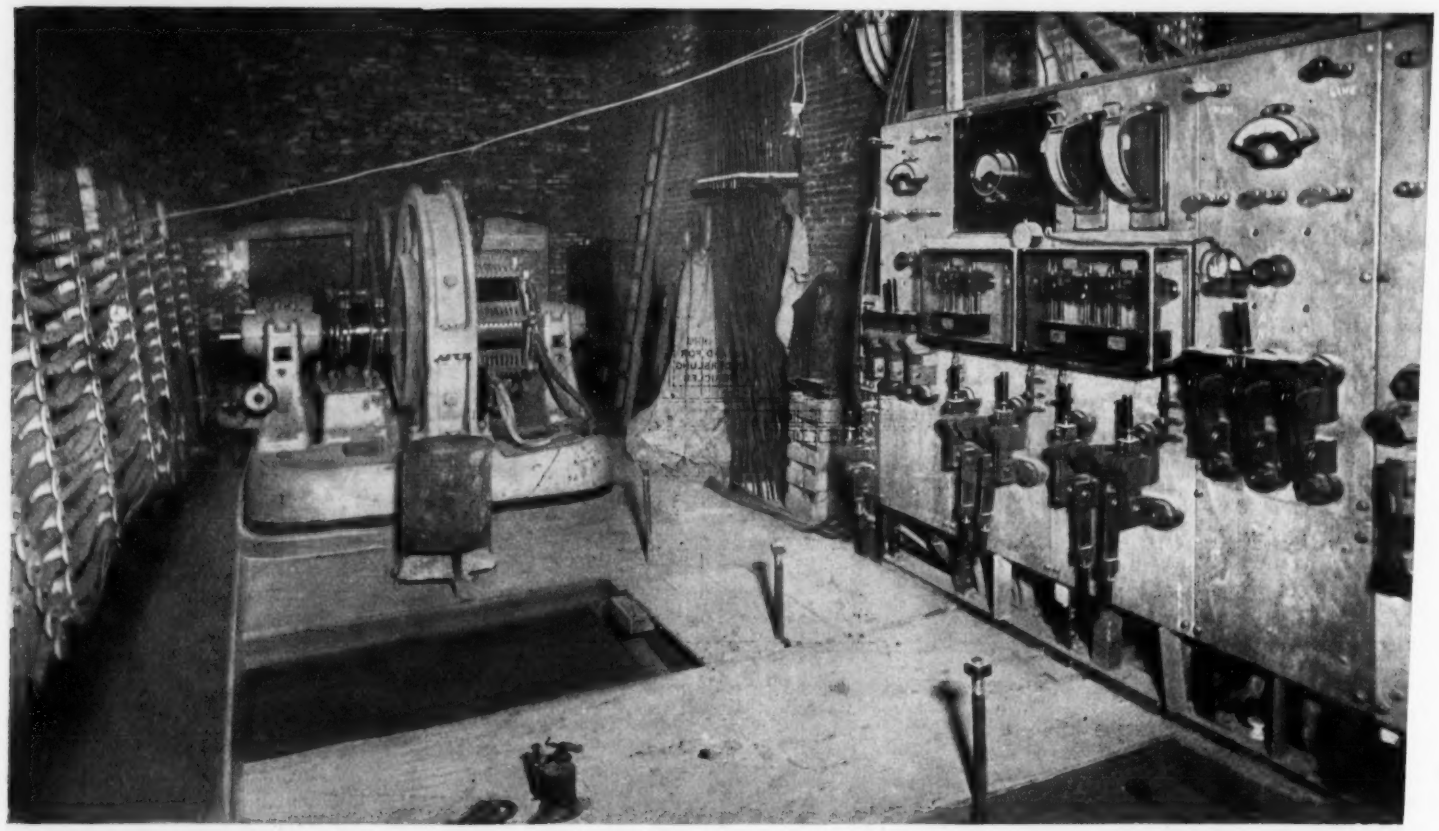


FIG. 2.—A CORNER IN THE ROTARY ROOM.

As will be noted, the charging process is carried on without the use of a voltmeter in the battery switchboard room. The only voltmeters necessary are those employed in the rotary room where the different bus-bar voltages are regulated.

Forty sections of the battery-charging switchboard are already installed, this represents 400 battery racks. As the necessity arises, other sections will be added, until the full capacity of the battery-charging room is reached, which is 1000 batteries. Fig. 3 shows a few sections of the battery-charging switchboard. From the switchboard room the charging current, as has been said, is conducted to the battery-charging room.

THE BATTERY-CHARGING ROOM.

This is a room 302 ft. long, 42 ft. wide and 20 ft. high, separated from the vehicle-loading room by a substantial partition of wood and glass.

The floor in this room is made up of a series of rectangularly-shaped spaces, formed by brick walls 8 ins. thick. These spaces are filled in with sand to a uniform level. A light layer of concrete is placed on the sand in which the cast-iron pedestal that supports the

FIG. 3.—BATTERY-CHARGING SWITCHBOARD—FRONT.

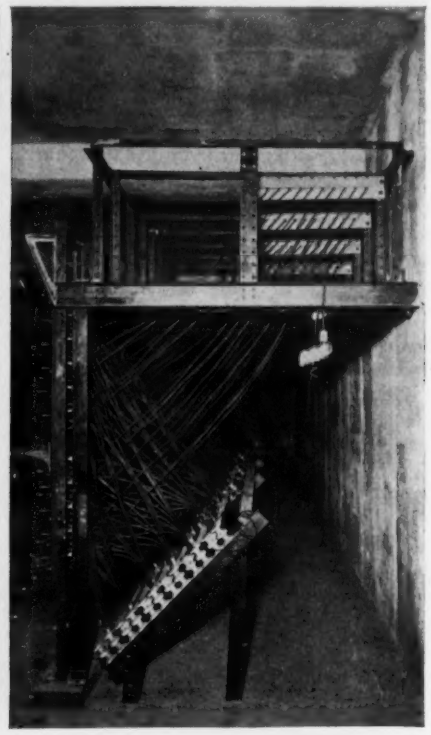


FIG. 4.—BATTERY-CHARGING SWITCHROARD—BACK.

battery-charging racks are set. Above this comes a finished floor of acid-proof concrete in which the pedestals are firmly embedded. Ten channels or conduits, in which the wires from the battery switchboard are carried, extend the width of the room at varying intervals, as may be seen in Fig. 1. From each of these, five smaller channels branch at right angles. These channels, or conduits, are formed by the spaces left between the walls of the rectangularly-shaped floor spaces spoken of above. Fig. 1 shows the arrangements of these channels very clearly. It may be noticed that the channel marked main A carries all the wires required to charge the batteries placed in the racks which line each side of the branch channels numbered 1, 2, 3, 4, 5, and which are on the eastern, or Eighth Avenue, side of main A.

The same arrangement is followed in the wiring of the other sections, each main channel feeding the branch channels, which are situated on its eastern side. The main and branch channels are lined with acid-proof concrete and the wires carried in them are kept in proper position and well separated by Alberine stone insulating slabs, placed

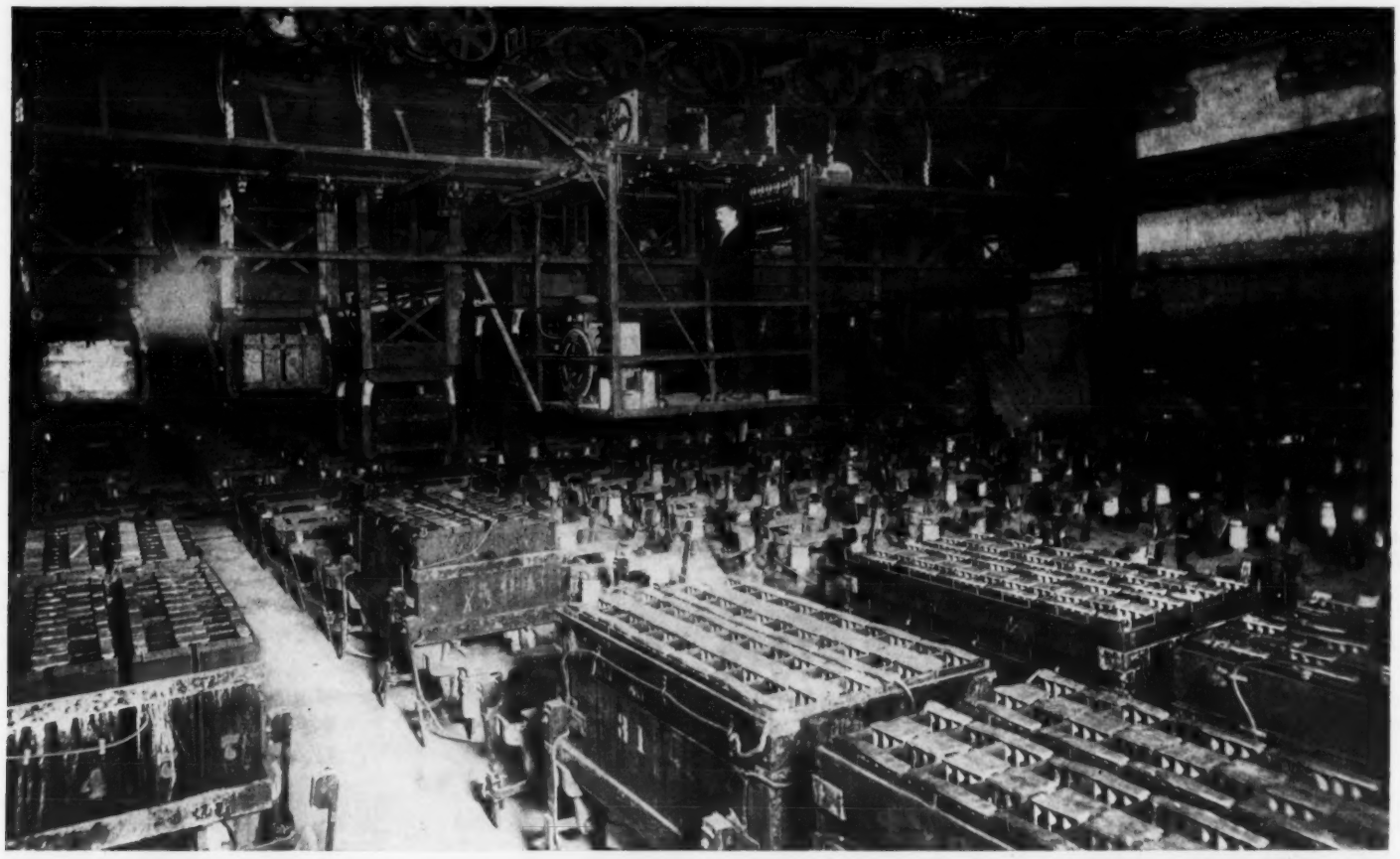


FIG. 5.—BATTERY ROOM AND CRANE.

vertically in the channels at convenient intervals. The wires pass through equally-spaced holes in the insulating slabs. By this arrangement, though in many of the main channels more than 70 separate wires are carried, each individual wire can be quickly and accurately traced from its switchboard panel to its battery rack.

A system of drainage for the battery floor is provided; each branch channel drains into its main channel and each main channel is connected, at its lowest point, with a pipe which runs the length of the battery room and finally discharges into the sewer.

The main and branch channels are covered with a wooden floor laid in small sections to facilitate its removal for inspecting the wires In this way a clear floor space is obtained, hardly a wire being visible to the casual observer.

Each battery rack, of which there are at present 640, consists of 4 cast-iron pedestals, 12 ins. high, firmly supported by the concrete floor. On each of these is placed a porcelain insulator, 7x4½ ins., held in place by cement. Resting on these insulators are two cast-iron racks—each independently supported on two insulators. Two U bolts, as shown in Fig. 6, hold these racks in place. Fig. 6 also shows the details of the contact-making arm which automatically connects the batteries to the charging circuit when they are deposited on the

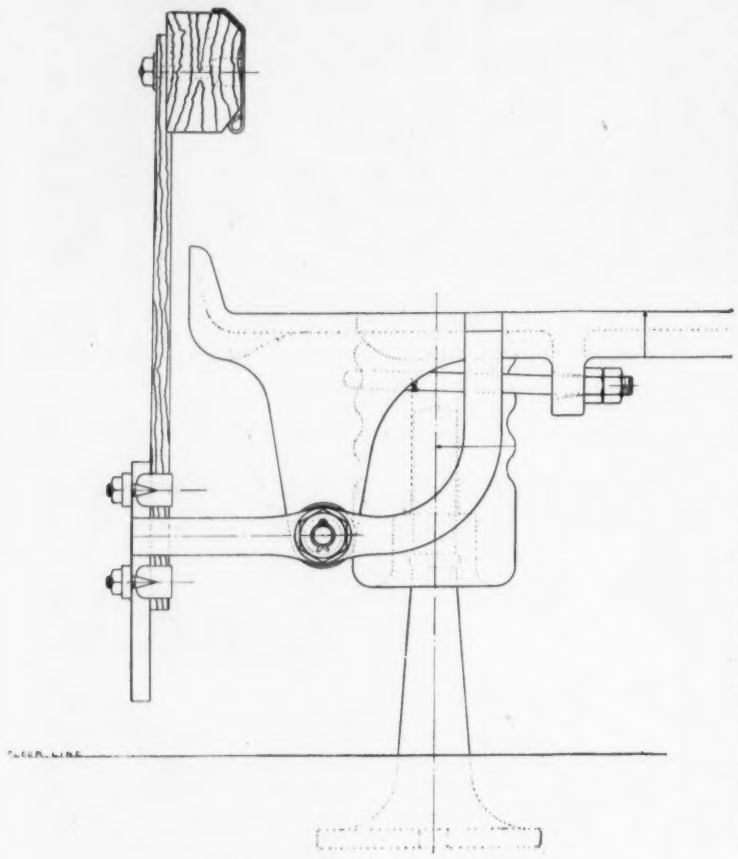


FIG. 6.—AUTOMATIC CONTACT ARM ON BATTERY RACK.

rack. There are four of these arms connected to each rack. The L-shape cast-iron arms, pivoted as shown, have fastened to their outer end a straight piece of hard wood, 15½ ins. long, covered with an acid-proof paint. At the free end of each wooden arm a contact block of hard wood is fastened. On the contact face of each block is placed a piece of brass, to which the charging wires, from the source of current supply, are connected. The operation of these arms is very simple. The weight of the descending battery depresses that portion of the arm which, when no battery is in place, protrudes slightly above the rack. Thus the brass-faced wooden blocks are forced against the contacts placed at the four corners of each battery box. The natural spring in the 15½-in. wooden arms assures a good contact. Each battery is connected in two groups of 22 cells, in such a way that by cross-connecting two diagonally opposite contact arms, the battery charges in series. The distance from the floor to the top surface of the charging rack is just one foot. The average height of a battery box is 1 ft. 6 in. Hence the top of each battery is on a convenient level for inspection of the cells, for filling them with acid and for reading their specific gravity, as seen in Fig. 5.

Each battery rack is connected to its special panel on the battery switchboard by a No. 6 wire, as has been explained. In each branch channel is a 400,000-cm common return cable to which each charging rack is connected. This in turn is fastened to two 1,000,000-cm cable, two of which are placed in each main channel. These are connected, as has been noted, to the direct-current panels on the low-tension board in the rotary room.

In a succeeding article, the apparatus for handling the batteries will be described in detail.

Electric Plant of the Manhattan Elevated Railway.—I.

WHILE the electrical equipment of the Manhattan Elevated Railway will not be completed in all of its details for some months yet, the work has progressed far enough to enable us to present an account of the main features of the installation. At present the steam and electrical machinery is in process of construction, the power house is approaching completion, and a great part of the third-rail conductor is installed. The first generating units are expected to be ready for use about June of this year, when they will supply current for the Second Avenue line.

When completed, the Manhattan plant will be by far the largest steam-driven electrical generating plant in the world, the only other coming within measurable distance being that of the Metropolitan Street Railway system. Its duty will be to supply current to 75 miles of third-rail, aggregating over 70,000 amperes, at 625 volts at the period of maximum load. The generators to supply this enormous amount of energy will be eight in number, each of 5000-kw normal capacity. Each machine will be 42 ft. high and weigh no less than 445 tons, the revolving field alone weighing 185 tons. While the mere magnitude of the plant renders it of especial interest, this is further enhanced to the electrical engineer by a number of the technical features involved, perhaps the most striking of which is the direct generation and distribution of current at 11,000 volts, almost twice the voltage of such modern plants as those of the Metropolitan Railway and the latest additions to the New York electric light and power central station system.

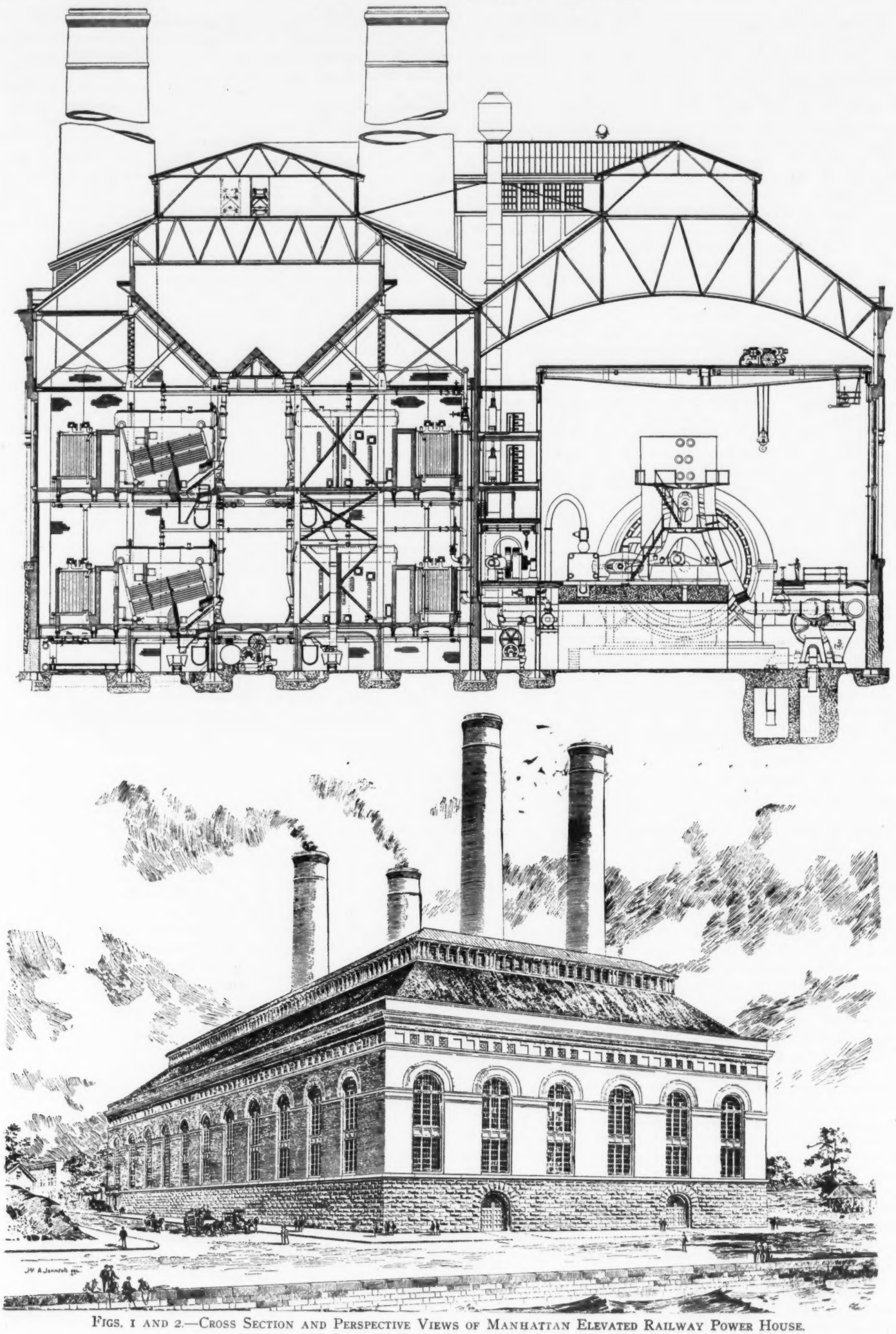
Another indication of the magnitude of the service which the plant will supply is given in the statement that the lighting of the power station, sub-stations, passenger stations, etc., will require 15,000 incandescent lamps and 250 arc lamps, this incidental use thus corresponding to the electric lighting demands of, for instance, Troy, N. Y.

The power house is located on the East River between Seventy-fourth and Seventy-fifth Streets. All the current is here generated at 11,000 volts and transmitted at this pressure to seven sub-stations, where it is transformed to a voltage of 390, and by means of rotary converters is converted to direct current at 625 volts. The generating station is designed for a maximum capacity of 100,000 horse-power which may, however, be extended to 150,000 horse-power by constructing an addition on a part of the plot left unoccupied.

A view of the power house as it will appear when completed is given in Fig. 2, and a cross section of the same in Fig. 1. As will be seen by referring to the latter figure, the building is divided by a longitudinal wall into two parts, forming a boiler house 104 ft. wide and a generator house 96 ft. 6 ins. wide. The length of the building is 395 ft. on Seventy-fourth Street and 413 ft. on Seventy-fifth Street. The boiler house contains a basement, two boiler floors and coal pockets located immediately under the roof. The height from the basement to the top of the monitor is 128 feet. The basement is divided into three compartment by two longitudinal walls, in the central one of which are located the pumps, the ashes being handled from the compartments on either side. The coal pocket has a capacity of 15,000 tons.

There are four chimneys, each 17 ft. inside diameter and 270 ft. high above the basement floor. These chimneys, which are the largest of the kind in this country, are built of "Custodis" brick, perforated with rectangular holes about 1 in. square in the direction of the height of the stack, thus making the cell walls about 1 in. thick. These holes serve to bond the bricks in the nature of tenon joints by flushing the mortar into them. The four chimneys contain no less than 30,000 cubic feet of concrete and 204,000 cubic feet of brickwork.

A bridge 20 ft. wide and 12 ft. high extends from the front of the boiler house at an elevation of 60 ft above the street, to a coal and ash tower, built at the water's edge, in which is located a coal crane. The tower contains a line of ash storage pockets extending along its length for 65 ft., from which the ashes will be dumped into barges by gravity, being guided by aprons folding up against the face of the tower when not in use.



FIGS. 1 AND 2.—CROSS SECTION AND PERSPECTIVE VIEWS OF MANHATTAN ELEVATED RAILWAY POWER HOUSE.

The coal will be discharged from barges at the dock and delivered into the bunkers, situated above the boilers, at the rate of 150 tons per hour by means of Mead coal conveying apparatus. In its passage the coal is passed through crushers and weighing hoppers.

After leaving the furnaces, the ashes pass through chutes to the basement and are conveyed to an ash pit at the river end of the building by means of dump cars, hauled by an electric locomotive. From the ash pit the ashes are carried to storage bins on the river front by a bucket conveyor.

The boiler equipment consists of 64 Babcock & Wilcox horizontal water-tube boilers of 500 horse-power each, arranged in batteries of two boilers each in four lines, as shown in Fig. 1. The boilers are capable of sustaining safely 200 lbs. working steam pressure and are fitted with Roney mechanical stokers capable of burning either hard or soft coal, either separately or mixed. It is interesting to note that to handle this boiler plant by flat grates and hand firing would require a force of about 270 men, which the employment of mechanical stokers reduces to 90 men.

Sixteen Sturtevant blowers will be used for furnishing forced draught. These are installed as an emergency provision for such contingencies as a sudden increase in load, unusually low barometer, combined with bad coal, neglect or bad judgment on the part of the fireman, or accident to some part of the plant requiring forcing of the remaining units. It was considered that the stoppage of the plant even for a few minutes would entail such loss and inconvenience to so many persons that no reasonable provision should be omitted to ensure continuous operation. Two blowers will be located on each boiler floor, one opposite each chimney, and each blower will supply two batteries of boilers. The blowers are 9 ft. in diameter, 4½ ft. wide, and will be driven by a direct-connected alternating-current motor running at 180 r. p. m.—alternating current motors being employed in this instance for the reason that the blowers will never be called for when the main generators are not in operation.

Sixteen Green economizers, located as shown in Fig. 1, are employed, each serving two batteries of boilers. The use of economizers in this plant is more than usually advantageous from the fact that all the auxiliary machinery is electrically driven; there is, therefore, no waste steam which could be utilized in auxiliary heaters for raising the temperature of the feed water.

Eight triplex, single-acting Goulds boiler-feed pumps will be electrically driven by means of 500-volt direct current motors.

The engines are being constructed by the E. P. Allis Company and will differ considerably from the types heretofore used in railway power plants. They are of the compound horizontal and vertical cross-compound type, and each unit consists of two compound engines working at either end of a generator shaft. The disposition of the two cylinders is shown in Fig. 1. The high-pressure cylinder, which is horizontal, is 44 ins. in diameter, and the low-pressure or vertical cylinder is 88 ins. in diameter, the stroke being 60 ins. and the speed 75 r. p. m. The normal rating corresponds to 8000 horse-power and the maximum to 10,000 horse-power. There thus being four cylinders to each shaft, the turning effort is very uniform—a great advantage in the parallel operation of alternators.

The eight engine foundations are approximately 40 ft. square and 21 ft. high, and have an archway through the middle 4½ ft. wide.

Under one side of the engine room are condensing tunnels which are of concrete in a rectangular excavation of bed-rock extending 20 ft. below the engine room floor. The intake tunnel is 8½ ft. wide from the rear of the building to the front, from which point it increases to a width of 14 ft. at the river, where the screen chamber is placed. The outlet tunnel is 5 ft. wide.

The Worthington condensers to be used are in several particulars of unusual design. Owing to the present uncertain state of the art as regards the extraction of cylinder oil from the water of condensation, and the possibility of radical improvements in this direction, it was decided that the installation should consist of jet condensers, so arranged that each can be changed or modified into a surface condenser hereafter, and at a minimum expense. One of the condensers is shown in Fig. 3. The air pumps are of the vertical triplex type, driven by a geared direct current motor at 30 r. p. m. when operating in connection with the jet condensers. By changing the ratio of the gearing they may be run at 10 or 15 r. p. m. when operating in connection with a surface condenser. The circulation of water through a surface condenser will be by means of a centrifugal circulating pump to be directly connected to the free or outer edge of the electric motor. Whenever it may be decided, therefore, to change this system to a surface condensing system, this may be accomplished by the mere addition of the necessary apparatus, the only portion of the present condensing system to be discarded being the condensing chamber of the jet condenser. Condensing water is supplied by the tunnels above referred to.

Feed water will be obtained from the city mains, but a centrifugal motor driven pump will be installed to supply river water to the boilers in case the city water is shut off for any cause. In the latter case salt water will, of course, be supplied, but the occasions when it will be necessary to resort to this measure will be very rare, as storage and surge tanks will provide a supply of fresh water sufficient to run the boilers for four hours at their maximum load. There are eight surge tanks, corresponding to the eight units, which receive the condensation from the steam pipes and reheaters of the engines, and all the water used in the water jackets around the engine bearings.

The steam piping consists of eight sections, each section connecting four batteries of boilers to one engine. Eight boilers are arranged in a group opposite an engine, and there is thus secured the shortest distance for the steam to travel. A steam reservoir 36 ins. in diameter and 24 ft. long is installed at each engine, from which a steam pipe runs to each of the two high-pressure cylinders of the engine. The steam reservoirs all connect together through headers. The design of this piping permits of alteration or repairs without any interruption in the operation of the plant. A 42-in. exhaust pipe is placed in the basement on the south side of the engine room, and in the centre of the building a branch runs below the engine room floor and is connected to a riser ending in an exhaust head above the roof.

The engine room is supplied with a 50-ton electric traveling crane and two small cranes, the latter for the purpose of handling the exciter engines and generators.

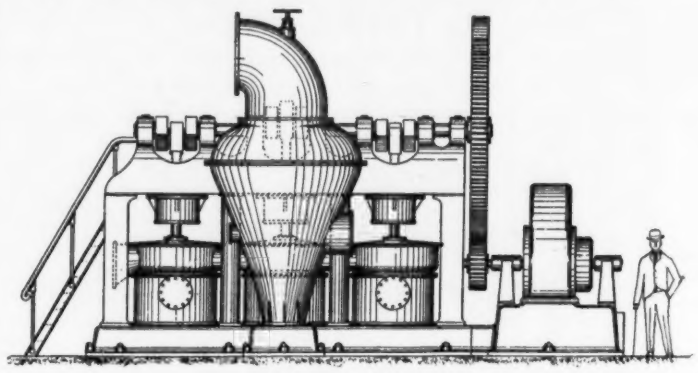


FIG. 3.—ONE OF THE CONDENSERS.

The engines driving the four exciters of this plant are of the tandem-compound piston-valve type, made by the Harrisburg Foundry & Machine Works, and have a nominal rating when running at 150 lbs. steam pressure, condensing, of 300 horse-power at 200 r. p. m. They are direct connected to 200-kw Westinghouse multipolar generators.

As stated above, all auxiliary machinery is electrically driven. For the purpose of starting the plant when the main engines are for any reason temporarily stopped, auxiliaries which are required to operate before the main engine can be started are provided with electric motors wound for 500 volts direct current. The current from the main generators being alternating, it is transformed for this purpose by means of transformers and rotary converters. A small storage battery is provided for the power station from which the electric auxiliaries can be driven should the main engines be shut down.

As previously stated, the lighting of the power station, sub-stations, passenger car stations, yards and miscellaneous buildings owned by the company, will require the use of 15,000 incandescent lamps and 250 arc lamps, corresponding to an output of about 1000 kilowatts. Since the current generated in the power station has a frequency of 25 p. p. s., it is necessary to provide apparatus for transforming this frequency to 60 p. p. s. in order that both arc and incandescent lamps can be operated on the same circuit. This will be done by the use of motor-generator sets located in the power house and in the several sub-stations. Each motor generator set will consist of a 25-cycle, 400-volt, three-phase induction motor driving a three-phase alternator generating current at 60 cycles and 2300 volts.

Each sub-station is made an independent center of distribution for the lighting load in its vicinity and distributes to the transformers along the line through triple conductor lead-covered cables. Two hundred transformers in two sizes, 3.2 kilowatts and 6.4 kilowatts, will be used to reduce the voltage from 2300 to 110 volts for incan-

descent lamps. About 100 16-cp incandescent lamps will be used at each station, thus producing a brilliant illumination.

Before entering into a description of the generating and sub-station plants, a brief account will be given of the third-rail installation.

The third rail used on the Manhattan Railway weighs 100 lbs. per

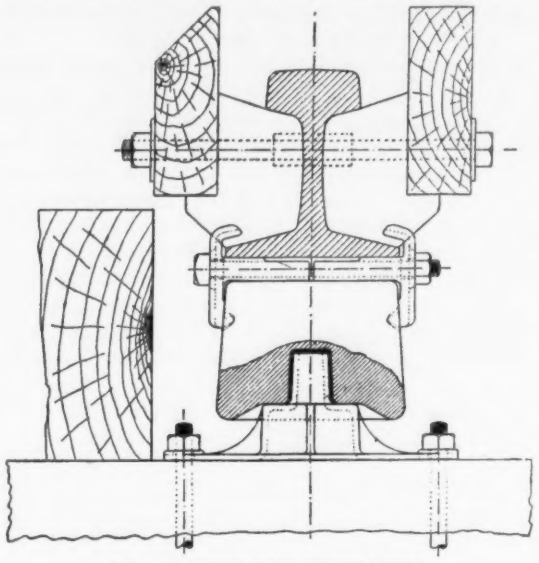


FIG. 4.—THIRD-RAIL INSULATION.

yard and is rolled in 60-foot lengths. Each section is the standard section of the Lackawanna Iron & Steel Company. An investigation as to the composition of iron giving the best conductivity, resulted in the adoption of the following formula: Carbon, .073 per cent; manganese, .341 per cent; sulphur, .073 per cent; phosphorus, .069 per cent.

While the use of this formula gives a rail so soft as to be unfit for ordinary railway service, its conductivity is only about ⅛ that of copper, while the conductivity of the traffic rail, used by the Manhattan Company, is only from 1-10 to 1-12 that of copper. The third rail has a cross-sectional area equivalent to about 1,560,000 circular mils of copper. Where the length of the track between stations does not exceed 6500 ft, and with car trains running on a fifteen-miles-per-hour schedule at one minute headway, the third rail alone is sufficient to maintain at the end of a section the voltage to within about 10 per cent of the sub-station voltage under average load conditions. The method of insulating the third rail from the track ties is shown in Fig. 4. A casting bolted to the tie supports an insulating block to which the rail is secured by a clip. The design of the rail clips is such as to allow the rail to expand lengthwise, and a sufficient clearance is provided to prevent undue strain on the insulators from deflection in the structure girders and jarring of the ties.

In order to provide for the expansion of the third rail it is divided into sections of five-rail lengths of 300 ft. each. These 300 ft. sections are securely anchored at the center by sectional anchor clips and the ends are connected by means of expansion bonds and expansion splice-bars, as shown in the right of Fig. 5. The bonding of the intermediate joints is illustrated at the left of Fig. 5. The cross-sectional area of copper in all of the third-rail bonds is 1,750,000 circular mils, or a little in excess to the equivalent section of the rail. The third rails, for two and three-track structures are cross-bonded at 300 ft. intervals with cable of 250,000 circular mils section. As will

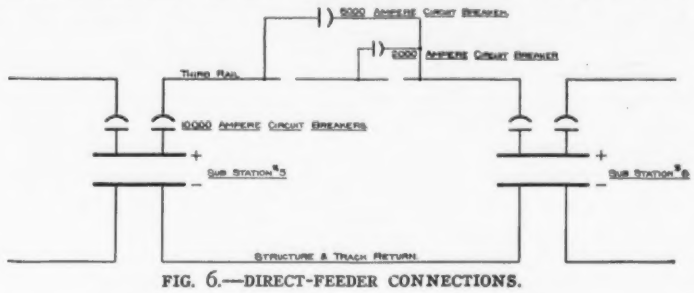


FIG. 6.—DIRECT-FEEDER CONNECTIONS.

be seen by reference to Fig. 4, there are wooden guard pieces secured to each side of the rail. These guards extend two inches above the rail and act as a safeguard against accidental shocks and burns to employes, and also to prevent fallen wire from causing short circuit

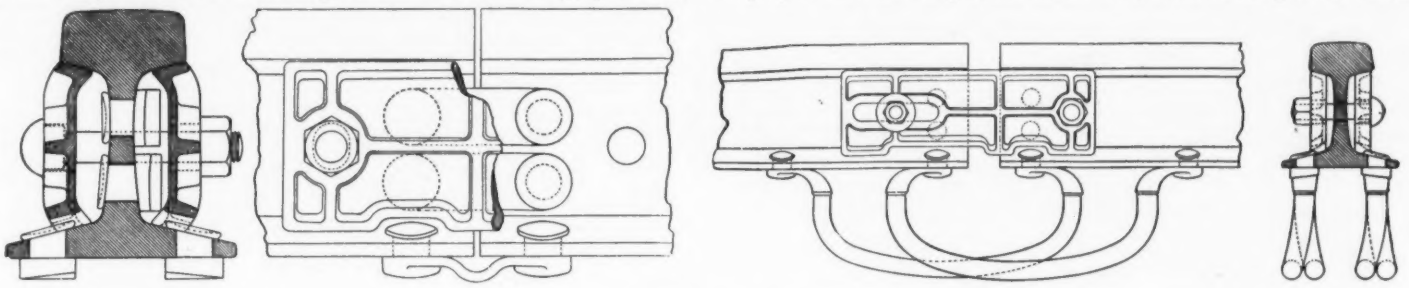


FIG. 5.—METHOD OF BONDING.

between the third rail and the traffic rails or other ground connection.

When supplementary feeder cables are required to keep the terminal voltages within economic limits, they are installed in a wooden box and supported on porcelain or vitrified clay insulators. The direct-current feeder sections are arranged as indicated in Fig. 6.

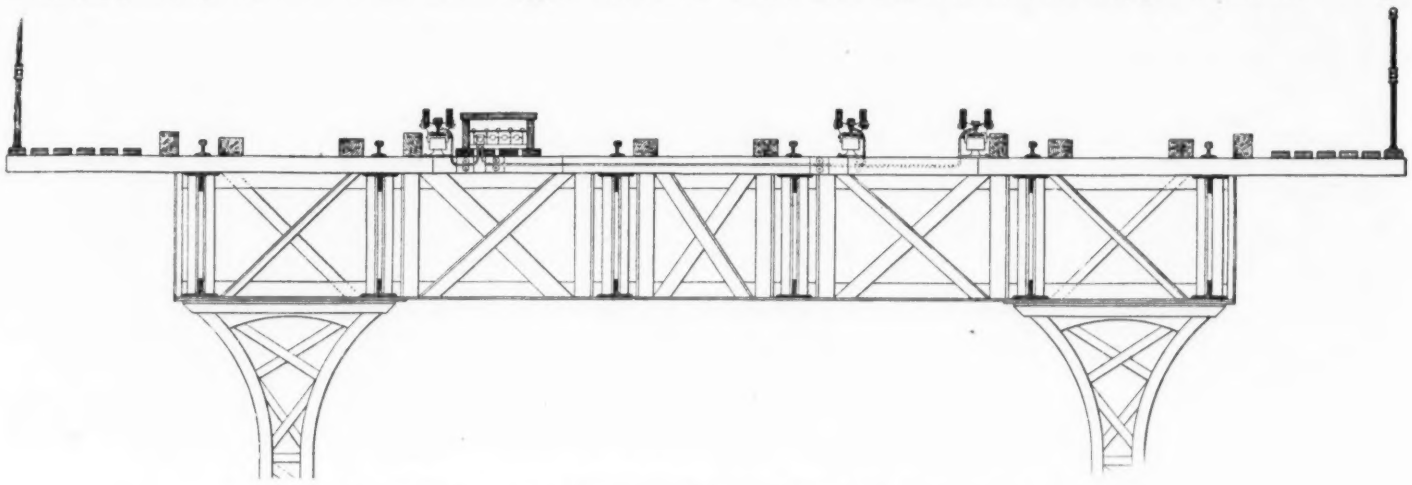


FIG. 7.—CROSS SECTION OF TRACK STRUCTURE, SHOWING THIRD RAILS AND FEEDER BOXES.

Each feeder is connected to a single circuit breaker at the sub-station, the ends of the feeders being also connected normally with a 6000-ampere circuit breaker. In order that a short circuit on one feeder section may not affect an adjoining section through the wiring of a motor car, a 2000-ampere circuit breaker is provided, as also

shown in the diagram. This circuit breaker supplies current to an isolated section of the third rail of such length that a motor car cannot span from one section to the next.

Feeder sections are designed so as to have approximately the same terminal drop in voltage, so that normally the current from one sec-

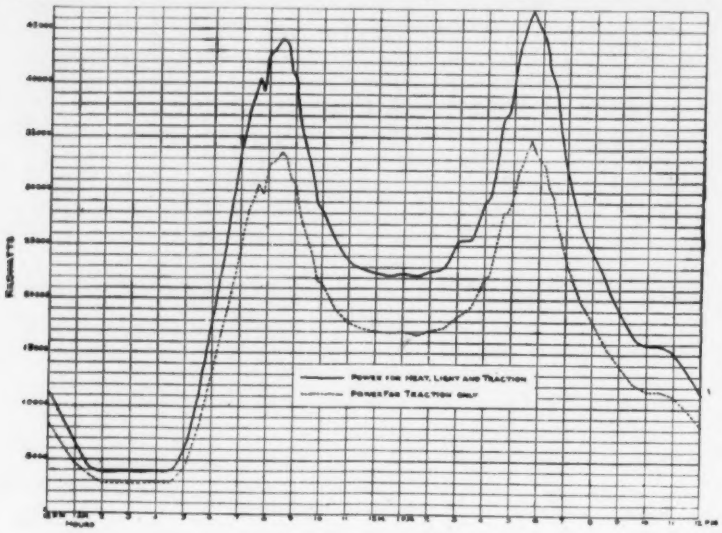


FIG. 8.—POWER CURVES.

tion to the next section is small. In emergencies, however, one sub-station may be shut down and the train service still maintained, though at a lower speed and with an increased drop in the voltage.

The return circuit is through the track rails and the elevated structure. The rails are bonded around the splice-bars with flexible bonds made up of No. 4-0 stranded cable welded to copper terminals. Holes in the rail are reamed and the terminals riveted by hydraulic compression. The track rails are bonded to the structure at intervals of 90 ft., and the longitudinal girders of the structure are bonded with from two to four No. 4-0 flexible bonds.

THE GENERATING PLANT.

The generators of the power plant—eight in number—were designed and are being constructed by the Westinghouse Electric & Manufacturing Company. Each generator is nominally rated at 5000 kilowatts, but is capable of delivering, during the hours of maximum traffic, 7500 kilowatts. As previously stated, the height of each of these machines is 42 ft., the calculated weight 450 tons, the diameter of the revolving part about 32 ft. and its weight 185 tons. The great weight of this revolving part enables the engine flywheel to be dispensed with, its effect combined with the approximate uniform effort due to four cranks angularly displaced on the generator shaft producing an extraordinarily uniform rotation.

The amount of power that will be required from the generators is indicated by the curves of Fig. 8, reaching a maximum of 60,000 electrical horse-power under the improved schedules by which trains will operate when the electric system is fully installed. The minimum power will be 5000 horse-power from 1 A. M. to 5 A. M., the average for 24 hours being nearly 30,000 horse-power. One alternator will be sufficient to carry the load from 1 A. M. to 5 A. M., but between 5 A. M. and 8 A. M. at least five additional generators must be connected to the circuits. After the maximum is reached at 8:30 A. M. the number of alternators rapidly decreases until 11 A. M. In the afternoon there is another peak in the load curve requiring the rapid connection of additional alternators, which later are again disconnected from the circuits. In the diagram, Fig. 8, the full curve represents the power for heat, light and traction, and the dotted curve the power for traction alone.

The generators are three-phase alternators delivering power at a voltage of 11,000. Three conductor cables distribute this power to step-down transformers in seven sub-stations, which lower the voltage to 390 volts, the alternating current then being converted to direct current at 625 volts. The three-conductor cables, illustrated in Fig. 10, are nearly 3 ins. in diameter and weigh about 9 lbs. per lineal foot. They will be installed in underground conduits, consisting of 28 vitrified clay ducts laid in cement and surrounded by concrete. A single-conductor cable will be used to transmit the 625-volt-direct current from the sub-station to the third rail.

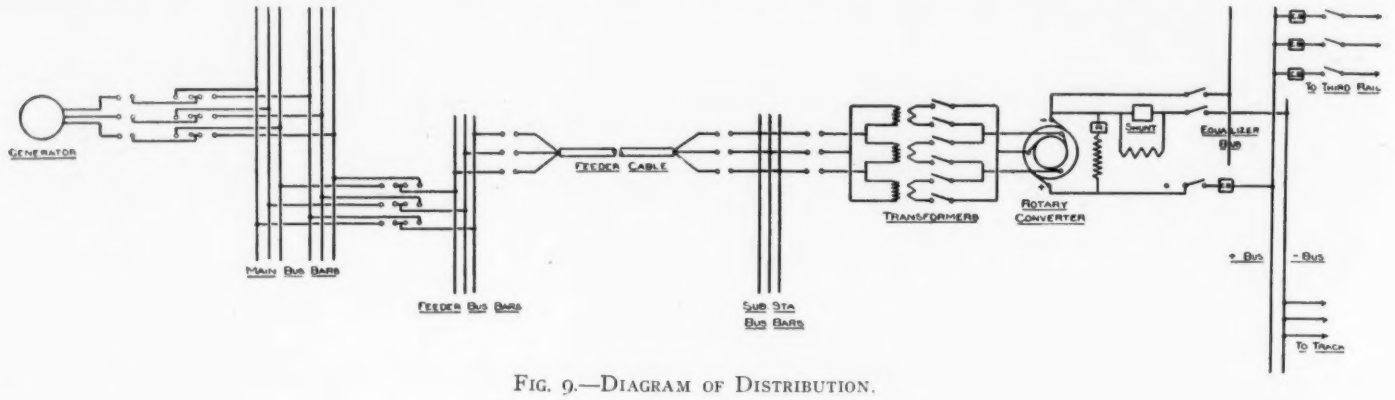


FIG. 9.—DIAGRAM OF DISTRIBUTION.

The system of distribution is very clearly shown in Fig. 9. From the generator the current passes to the main switchboard, the arrangement of which will be described in detail in a following article. Thence it proceeds to the feeder switchboard, from which it is conveyed to the sub-station switchboard by the three conductor cables. After being lowered in potential by transformers and converted into direct current by rotaries, the current is conducted to track feeders and thence to the third rails.

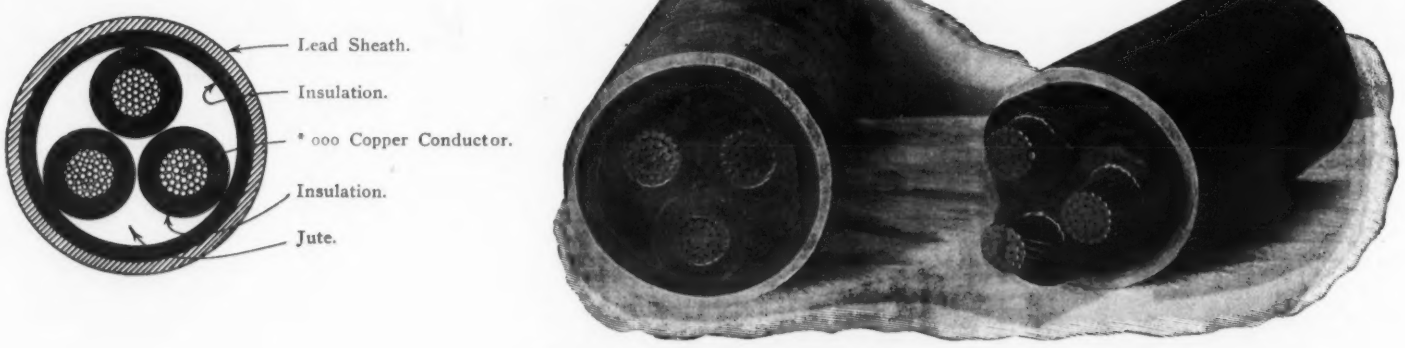


FIG. 10.—THREE-PHASE CABLE.

The Steam Turbine—III.

(*Concluded.*)

AS has been already stated, a jet of steam issuing through a properly-constructed orifice has as much energy as the same steam performing high ratios of expansion behind a piston. In both cases the work to be theoretically abstracted from a given

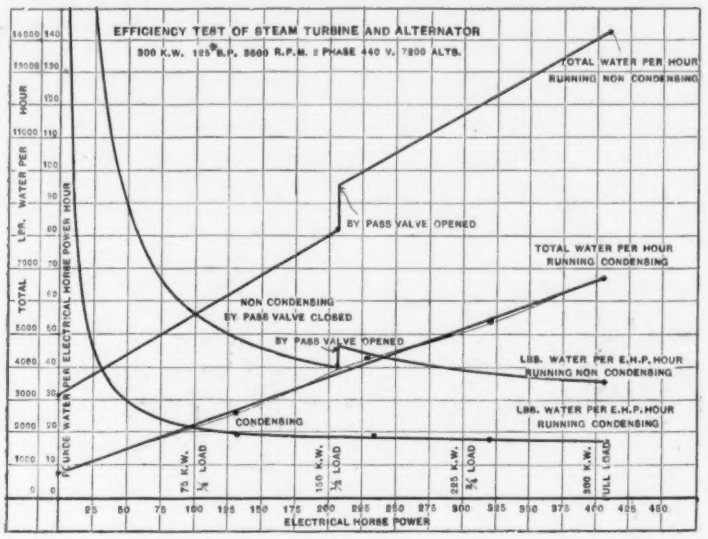

EFFICIENCY TEST OF STEAM TURBINE AND ALTERNATOR
300 K.W. 125 B.P. 3600 R.P.M. 2 PHASE 440 V. 7200 ALTS.
TOTAL WATER PER HOUR RUNNING NON CONDENSING
BY PASS VALVE OPENED
TOTAL WATER PER HOUR RUNNING CONDENSING
NON CONDENSING BY PASS VALVE CLOSED
BY PASS VALVE OPENED
LBS. WATER PER E.H.P. HOUR RUNNING NON CONDENSING
LBS. WATER PER E.H.P. HOUR RUNNING CONDENSING
CONDENSING
TOTAL LBS. WATER PER HOUR
LBS. WATER PER ELECTRICAL HORSE POWER HOUR
75 K.W. ¼ LOAD
150 K.W. ½ LOAD
225 K.W. ¾ LOAD
300 K.W. FULL LOAD
ELECTRICAL HORSE POWER

FIG. 15.—CURVES OF TURBINE TEST.

weight is the same; however, there are some practical reasons for expecting better results in the case of the turbine.

In the design of a three or four-stage compound condensing reciprocating engine it is found that there is no gain in economy by expanding the steam in the low-pressure cylinder beyond a terminal pressure of about 5 or 6 lbs. absolute. To do this means increasing very much the volume of the low-pressure cylinder, thus increasing the friction of the engine and the weight of the reciprocating parts. Moreover, the temperature of saturated steam, as these low pressures are reached, falls off much more rapidly, and hence there are greater losses, due to condensation and re-evaporation than would be gained by a more complete expansion. In the steam turbine no such limits exist. The extra volume of the low-pressure end does not add to the friction. The temperature conditions, from end to end, remain always the same, and hence such losses as condensation and re-evaporation are not in evidence.

Turbines are constructed to utilize the energy of the steam down to the utmost limits. A condensing steam turbine, when in operation, affords a striking example of the conversion of heat into energy. The temperature of the walls of the cylinder at the high-pressure end, about 365 degs. F, falls in the distance of three or four feet, to a temperature of about 126 degs. at the low-pressure end.

Some economy curves, developed from tests made on one of the 300-kw turbines, now in operation at the Westinghouse Air Brake Company's Works, are shown in Fig. 15. The results may be summarized as follows:

Full load, 16.4 lbs. steam per ehp-hour; three-quarter load, 17 lbs.; half load, 13.2 lbs.; quarter load, 22 lbs. The vacuum was 26 to 27 ins., the boiler pressure 125 lbs. per sq. in., and the speed 3600 r. p. m.

The consumption of 16.4 lbs. of steam, at full load, is in itself remarkable, but such results as at the light loads have never been approached before. It may be said that the consumption at half load is only 10 to 12 per cent greater than at full load.

It must not be lost sight of that these results are per electrical horse-power. It is usually the custom of engine builders to publish their results, per indicated horse-power, which means very little to the power user. He is chiefly interested in the economy of steam per unit of power he gets out of his power plant, not the steam per unit of power he has to put into it.

To make a comparison with a reciprocating engine and assume the efficiency of transmission from the steam cylinders to the switchboard to be 85 per cent, which is about the very highest attainable, would bring the full load water rate on the turbine, just described, to 14 lbs. per indicated horse-power. The tests were made under ordinary conditions, so far as dryness of steam is concerned, the boilers being some distance away, and no allowance made for wetness of steam.

In Fig. 15 is a set of lines showing the efficiency when running non-condensing. These results are somewhat inferior by reason of this particular turbine being designed essentially for condensing. Nevertheless, the results are not so bad as to preclude it being operated under these conditions, should at any time the condenser be out of order. A turbine, designed for running non-condensing, gives proportionately as good results as the condensing curves shown on the diagram.

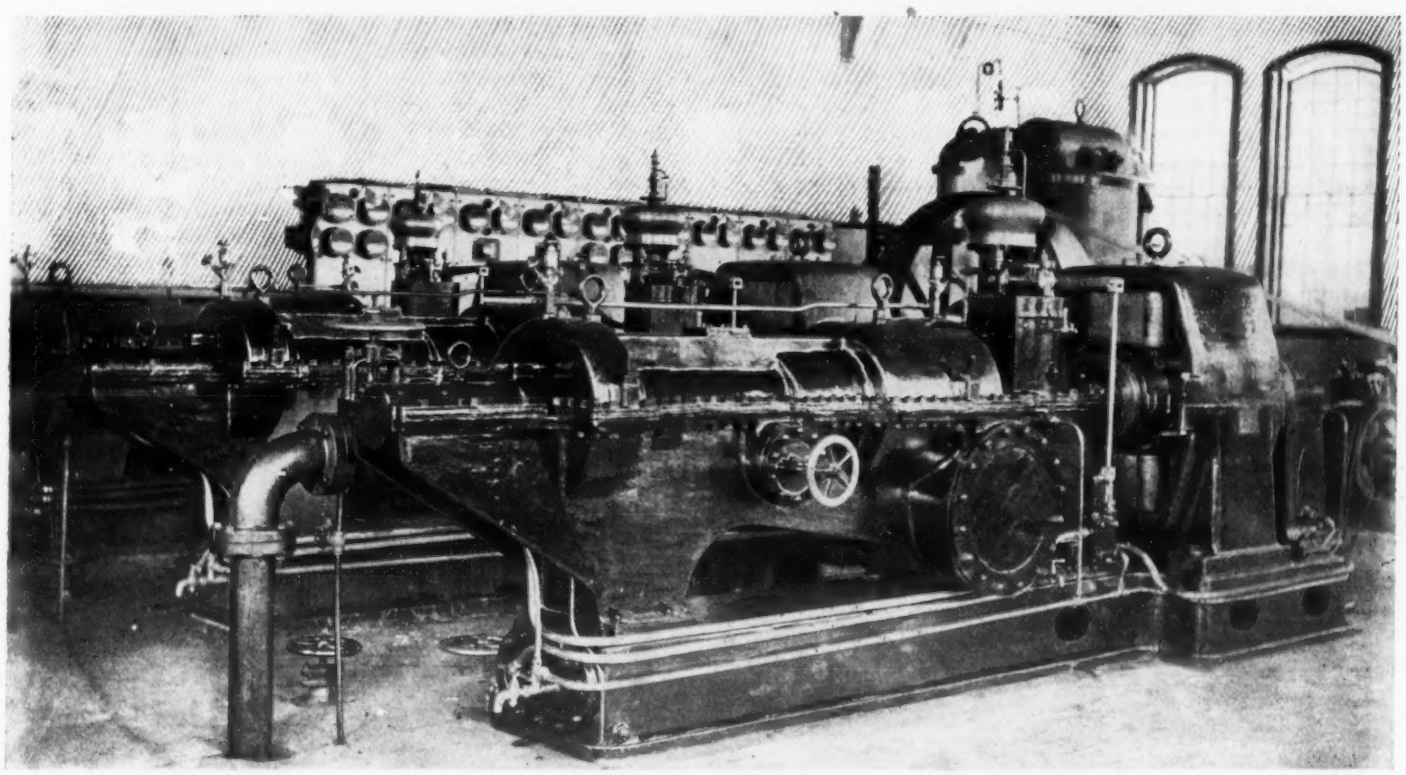


FIG. 16.—TURBINE-DRIVEN POWER PLANT.

By this set of curves may be observed the function of the by-pass valve. When running non-condensing the by-pass valve remained closed until about half load was reached. Upon being opened the efficiency fell off, as shown, and continued to improve from there on as

the load increased. The overload capacity of the engine is obviously more flexible than that of most engines.

Superheating may be made use of with considerable gain in economy and without the usual difficulties. There are no internal rubbing surfaces and no packing glands to become injured by the high temperature. Sixty to 70 degs. of superheat improves the economy by some 20 per cent.

In this connection Prof. Thurston has lately recorded some experiments with a de Laval turbine. For every 3 degs. F. of superheat 1 per cent of gain in economy was attained. With 37 degs. of superheat the capacity of the turbine was doubled. This gain he attributes almost entirely to the reduction of skin friction.

The practical efficiency of a turbine power plant may be gathered by some tests made by the Westinghouse Air Brake Company. After the plant had been installed some nine months the whole plant was shut down, and the steam engines, which had been previously doing the work, were connected up again, put in service and were kept running a week, during which time careful measurements were taken of fuel and water. After this the turbine plant was again put in operation and similar measurements were made with the electrical transmission. The saving in coal averaged 35.7 per cent during the day and 36.4 per cent during the night in favor of the turbines. The saving in feed water averaged 29.8 per cent. during the day and 41.4 per cent during the night. In round numbers this means a saving of 40,000 lbs. of coal in 24 hours. The gain is, in a great measure, due to the economy of the turbines, but also to some extent to the elimination of the condensation in long lengths of steam pipe and to the advantages of electrical transmission.

Fig. 16 gives a view of this power plant. The whole outfit of three turbines and generators, aggregating 1500 horse-power, occupies a floor space of 24 ft. square, and allows ample room for access to the turbines. The turbine and generator are shown separately in Fig. 17. The total weight is about 25,000 lbs.; total length, 19 ft., and width, 4 ft. 3 ins.

Lately a 1000-kw outfit has been built by C. A. Parsons & Company for the Elberfeld Corporation, in Germany. At 1200 kilowatts, 130 lbs. boiler pressure, 18 degs. F. of superheat, the turbine driving its own air pump, etc., an electrical horse-power was produced for 14.025 lbs. of steam. This is probably the highest economy ever attained in any steam engine.

Fig. 18 shows the complete revolving part of a 3000-hp turbine. Its weight is 28,000 lbs.; length over all, 19 ft. 8 ins., and 12 ft. 3 ins. between bearings; the largest diameter is 6 ft. The turbine, of which this forms a part, is shown in Fig. 19, and is being set up in the power-house of the Hartford Electric Light Company. It is direct-connected to a 1500-kw generator, the total outfit having the following dimensions: Thirty-three ft. 3 ins. long; 8 ft. 9 ins. wide; 175,000 lbs. total weight, including generator. This is the largest steam turbine in one integral part ever built.

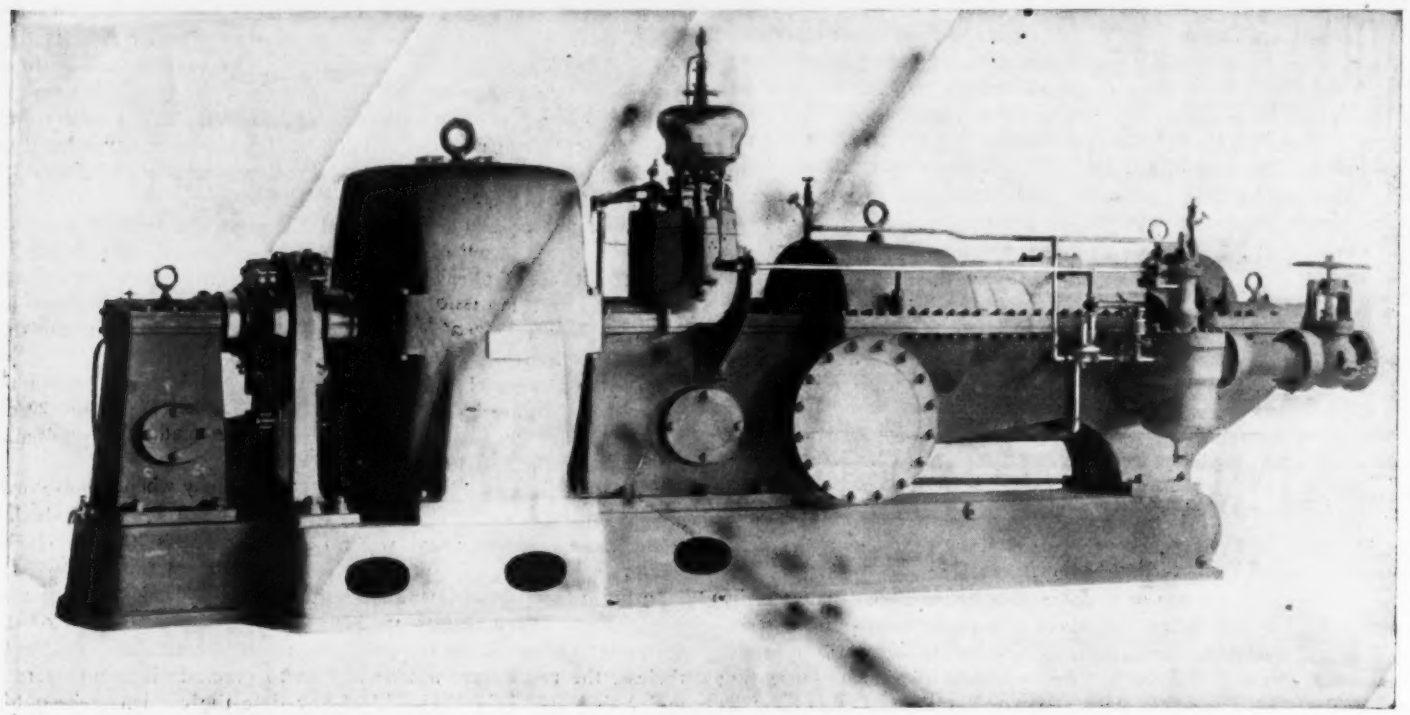


FIG. 17.—500-HP STEAM TURBINE.

As there are no rubbing surfaces in the turbine, no internal lubrication is necessary. This enables surface condensers to be employed and the condensed water used for boiler feed without fear of getting grease into the boilers. The turbine is entirely automatic in all its functions, and requires remarkably little attention. The only real working part is the spindle revolving in its bearings. These bearings are found to wear, but little, if at all, so the cost of renewals and repairs is very small.

In 1897 the Newcastle & District Electric Lighting Company of England published its costs in this regard. The power-house contained 11 turbines of 75 to 150 kilowatts each. The cost for repairs and renewals amounted to 26 cents per kilowatt per annum, and included all repairs to boilers, turbines, condensers, pumps, generators, cables, fittings, etc.

By reason of the turbine making use of the last available expansion

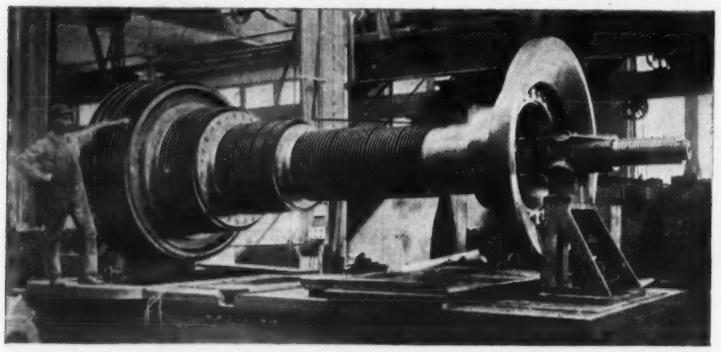


FIG. 18.—REVOLVING PART OF 3000-HP TURBINE.

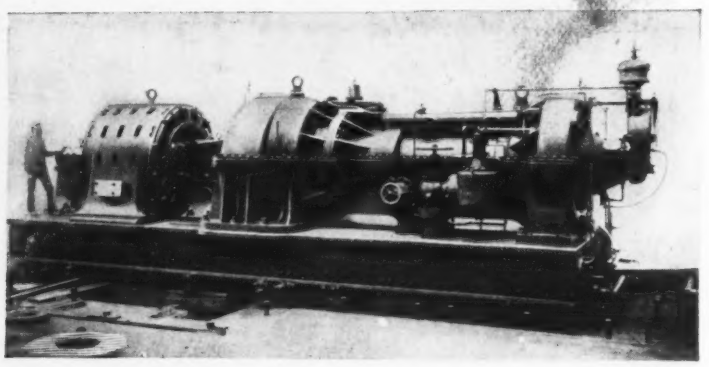


FIG. 19.—1500-HP TURBINE.

of the steam there is considerable advantage in employing the highest vacuum. For instance, considering the 300-kw turbines described, and assuming the steam consumption with 27 ins. vacuum to be 16.35 lbs. per electrical horse-power, it may be reasoned upon a thermodynamic basis that with the same machine designed for 25 ins. vacuum the consumption would be 18 lbs. per ehp-hour. On the other hand, by designing the same turbine to suit an exhaust pressure of, say, 29 ins. vacuum, the consumption would come down to 14.12 lbs. per ehp-hour.

The applications of steam turbines are perhaps not so universal as for ordinary steam engines. They are pre-eminently suitable for driving electrical machinery, particularly alternating current dynamos. Some difficulties are, however, experienced with the commutation of continuous current generators of fairly large powers.

There is nothing remarkable in the design of generators for this purpose, except the modification necessitated by the high speed. For this reason they are remarkable for their small weight and dimensions and the absence of crowded pole pieces.

Builders of electrical machinery have for some years been working in the direction of reducing speeds from the old bolt-driven rigs to admit of direct-connection to slow-going reciprocating engines. The condition for steam turbines is, however, a step in the reverse direction. Turbines have been used with good success in England for driving fans and blowers.

Although the type of bearing employed is capable of successfully dealing with about any reasonable error in balance, at the same time it is very essential that the revolving parts be very accurately balanced, in order that the collector rings and commutators may run true, and that the clearance between the tips of blades and walls of the turbine cylinder may be maintained as fine as possible; thus balancing forms quite an important stage of the construction and has many interesting features. The usual method of balancing, which consists of rolling the piece on ways and thus locating the heavy side, is sufficiently

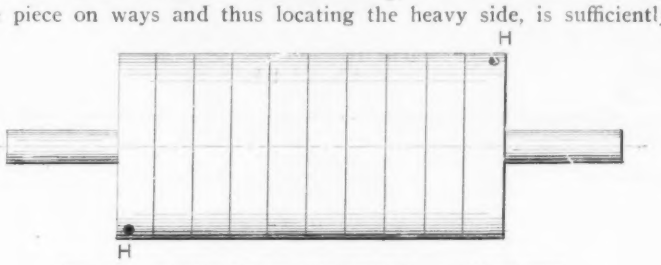


FIG. 20.—ILLUSTRATING ONE METHOD OF BALANCING.

accurate for ordinary slow-speed work, but no degree of real accuracy can be attained.

Attempting to balance a body, such as that shown in Fig. 20, by this method, might result in a heavy spot at two opposite sides and two opposite ends, as at *H*, *H*, which would be anything but a condition of good running balance. It is, therefore, found desirable to split this up into comparatively narrow rings and balance each separately, when the above error would become negligible. For balancing such rings the Westinghouse Machine Company has devised a machine which performs the work with remarkable accuracy. A turnable is pivoted on a beam, which is in turn hung on two knife edges. Below the turnable is rigidly attached an adjustable counterweight. The turntable, of course, is free to turn independently of all this. Means are provided to slide the whole turntable and counterweight in the beam and in a direction at right angles to the line of the knife edges.

The counterweight is adjusted to bring the combined center of gravity in a plane close to the knife edges. Then by sliding the mass in the beam the table may be made to rest horizontally. Then by giving the turntable one-half revolution the table will fall over by twice the amount it is out of balance. Readings are taken in two opposite directions and the exact location and the amount of the error may be immediately figured. Balancing by this method may be done very rapidly and with surprising accuracy. A ring weighing 6000 lbs has been balanced within 2 oz., and rings weighing 200 or 300 lbs. within ⅛ oz.

In the case, however, of the revolving parts of electric generators the final winding, etc., is liable to throw it out of balance, and then there is no alternative but to balance it in its entirety. The shape is generally of the nature of a long cylinder with a journal at both ends. The only way then to do this balancing is to deliberately mount it on bearings which are preferably set on springs and running it up to speed by belt or any available means. While running, it is marked with a colored pencil at different points, which serve to indicate where to add weight. In the case of a small body revolving at 5000 or more r. p. m., the light side is always the side that comes outward, so that weight should be added just where the marks come. In some cases the marks are opposite at each end, when weight needs to be added on one side at one end and on the other side at the other end. These facts show that when high speeds are reached the body ceases to revolve on the geometric axis and takes the axis of gravity.

On its way up to speed there is generally some point at which there is considerable vibration. This is termed the critical speed, and seems to come at the time when the body is changing its axis of revolution. These critical speeds become lower as the bodies are heavier and of greater radius. In the cases of heavier and bigger bodies, which also would have a lower rotative speed, the marks do not come just on the light side. They may come sometimes as much as 90 degs. ahead of the light side. The exact angle can only be found by experiment, and at best this is only a cut-and-try method. With experience, however, work may be put in very accurate balance.

The application lately of steam turbines to marine propulsion is well known. Some particulars of the vessels equipped may be interesting. The first vessel, named the "Turbinia," was built with a view of exploring the possibilities of turbines for this purpose. It was, therefore, built as small as possible, and at the same time not so small as to preclude the attainment of high speed should the experiments turn out a success. The dimensions selected, therefore, were 100 ft. long, 9 ft. beam, 3 ft. draught, and 44 tons displacement. It will be noted that the ratio of beam to length is unusually small, 9:100, while 10:100 or 11:100 is the more usual practice for this class of boat.

To begin with, the boat was fitted with one single turbine and propeller. The result was disappointing, the chief trouble being due to cavitations in the propeller, resulting in excessive slip. This was verified by experiments in a tank of water subjected to vacuum. The appearance of the action of the propeller in the water was observed by looking through a slot in a disc which was made to revolve in synchronism with the propeller under observation.

It was then considered necessary to make several changes. New engines were built in three sections, the steam expanding through them in series, each section driving an independent shaft, and each shaft three propellers. Very soon 32¾ knots were attained and eventually 34½ knots at the naval review at Spithead in 1897.—About 2300 ihp were developed. The boiler, a Yarrow type with small tubes, had 1100 sq ft of heating surface and an evaporation of about 28 lbs. of water per sq. ft. heating surface at 34½-knot speed. About 600 hp were developed per ton of machinery and 50-hp per ton of total weight of vessel in full equipment.

These successes resulted in a contract with the British Admiralty for a torpedo boat destroyer named the "Viper." The dimensions were the same as the 30-knot destroyers of her class, 210 ft. long, 21 ft. beam, and 350 tons displacement. The engines consisted of two independent sets, each consisting of one high-pressure turbine driving a shaft, and one low-pressure turbine driving its shaft. On the same shaft as the low-pressure was permanently connected a small turbine for reversing purposes. When running ahead the reversing turbine was in connection with the condenser, so that the frictional losses, due to this turbine running idle, were very small. The same fact applies to the go-ahead turbines when running astern.

There were, therefore, four propeller shafts, each fitted with two propellers, the one ahead having a slightly lesser pitch than the after ones. The Yarrow type boilers have 15,000 sq. ft. heating surface, grate surface 272 sq. ft.; condensers have 8000 sq. ft. surface. The speed attained was 35 knots to begin with, and later 36.858 knots were reached.

It is generally conceded by engineers that but little more may be anticipated in the development of the reciprocating engine. Any improvement that we can imagine would not very materially improve its efficiency as a heat engine. On the other hand, the turbine is capable of development in many ways, particularly in the use of superheated steam, to a degree hitherto prohibitive, so that the day may not be very far distant when the turbine will replace the reciprocating steam engine for most purposes.

"Duplex Telephony."

The Chicago Telephone Company a few days ago sent out a circular urging its customers to have their telephone business double-tracked—one instrument for outgoing business and one for incoming. Some smart local reporter who got hold of it thought it was a plan for "duplex" telephony and so heralded it to a startled public. General Manager Hibbard has been kept busy explaining the thing to his telephonic friends in different part of the country.

Twenty-Five Great Names in Electrical Science and Invention During the Nineteenth Century.

The lists which appear on the opposite page were compiled from individual lists received in response to invitations sent to the membership of the American Institute of Electrical Engineers for an expression of opinion as to what names connected with electrical science and invention during the century just closed, should appear on a list of twenty-five greatest names; and an indication by numerals of the names which, in their opinion, should be assigned first, second and third rank, respectively.

In response to this invitation 277 ballots were received and from these the general list on the opposite page was compiled. In order that an interesting comparison might be made with the general list, the two other lists printed with it were compiled as follows: From the 277 ballots those of twenty-five professors of electrical engineering were selected; also twenty-five ballots signed by leaders in various branches of electrical application and others whose opinions were thought to have particular weight. From these two sets of selected ballots the comparative lists, "A" and "B" were prepared.

The closeness of the vote of the first thirty names on the tally sheets was quite remarkable; in a number of cases the vote was a tie and this is indicated on the lists by braces opposite the names. On the general list tally sheet there was a difference of but seven votes between the twenty-fifth and the thirty-first names, and had the list been extended to the latter number it would have included the following names in the order given: Weston, Hopkinson, S. P. Thompson, Weber, Ferraris and Gray. Similarly, the tally sheet of the ballots cast by twenty-five professors of electrical engineering, if extended to thirty names, would have included Gauss, Wheatstone, Ewing, Röntgen and Rowland, the three last mentioned having but three votes less than the twenty-fifth on the list. Had the selected engineers' list been extended to thirty names it would have included Hopkinson, Marconi, Heaviside, Pacinotti and Steinmetz—the difference between the vote of the last mentioned and number twenty-five on the list being also three.

FARADAY

MAXWELL

KELVIN

EDISON

On the general list, there were practically but seven selections for the first, second and third places, and in the following order: Faraday, Kelvin, Edison, Maxwell, Henry, Morse and Bell. Faraday received almost twice as many votes as any of the others, and the vote of the next three names was largely in excess of the final three. On the professors' tally sheet, Henry stood fourth, the other names below his receiving but a few votes each. On the engineers' list Edison was fourth, the subsequent names also receiving but a few votes each.

The name Siemens should be accepted as standing for the family rather than for any particular member thereof.

Result of Vote Upon Twenty-five Greatest Names in Electrical Science and Invention During the Nineteenth Century

SELECTED LIST

A

Compiled from Ballots of 25 Professors of Electrical Engineering,

(Exclusive of Ballots in List B)

1. FARADAY
2. KELVIN
3. MAXWELL
4. EDISON
5. HENRY
6. HERTZ
7. E. THOMSON
8. BELL
9. MORSE
10. AMPÈRE
11. SIEMENS
12. DAVY
13. HELMHOLTZ
14. OHM
15. TESLA
16. HOPKINSON
17. BRUSH
18. OERSTED
19. FERRARIS
20. GRAMME
21. PLANTÉ
22. STEINMETZ
23. JOULE
24. SPRAGUE
25. WEBER

GENERAL LIST

Compiled from Ballots of 277 Members A. I. E. E.

(Inclusive of all Ballots)

1. FARADAY
2. KELVIN
3. EDISON
4. BELL
5. MORSE
6. HENRY
7. TESLA
8. E. THOMSON
9. MAXWELL
10. AMPÈRE
11. SIEMENS
12. OHM
13. HERTZ
14. DAVY
15. BRUSH
16. WHEATSTONE
17. HELMHOLTZ
18. GRAMME
19. STEINMETZ
20. ROENTGEN
21. SPRAGUE
22. PLANTÉ
23. MARCONI
24. OERSTED
25. JOULE

SELECTED LIST

B

Compiled from Ballots of 25 Prominent Members A. I. E. E.

(Exclusive of Ballots in List A)

1. FARADAY
2. MAXWELL
3. KELVIN
4. HENRY
5. BELL
6. EDISON
7. AMPÈRE
8. MORSE
9. OHM
10. DAVY
11. HERTZ
12. SIEMENS
13. TESLA
14. GRAMME
15. HELMHOLTZ
16. WHEATSTONE
17. PLANTÉ
18. E. THOMSON
19. ROENTGEN
20. BRUSH
21. GAUSS
22. WEBER
23. JOULE
24. OERSTED
25. FERRARIS

ELECTRICITY IN THE TWO CENTURIES

XIX XX

Retrospect and Forecast

Electricity in the Coming Century.

By Elihu Thomson.

THE rôle of a prophet is certainly a very difficult one, and he treads dangerous ground who attempts to say in what direction future advance will take place. New discoveries may at any time change the course of events and open up paths of development now unknown. Whatever is said of the future of our science must of necessity be based upon present indications, as well as upon our imagination, and, it may even be, upon our hopes. There are certainly problems enough still unsolved; plenty of work for the young, fresh and bright minds, the deft and painstaking experimenters of the future. In the past, valuable resources have been shamefully wasted and they are still often used without much regard to economy. If necessity be really the mother of invention, the future higher cost of fuel must force the adoption of economical means for utilizing heat. Without doubt the gas engine, the steam engine using superheated steam, and the secondary engine using a volatile fluid boiled by the heat of exhaust steam will grow in importance in the immediate future. We must see that America is not backward in these advances, even though she may not feel the fuel scarcity for a long time. That electrical energy can give a higher yield of light than it now does in the usual electric lamps is abundantly proved. The Nernst lamp and the discharge in gases under proper conditions may produce 1 candle per watt. It is well known that the condensed spark discharge in air is a more efficient light producer than the electric arc, but as yet no thoroughly practical means for utilizing these more efficient light sources has been developed. With lamps of 1 watt per candle and with large gas engines of efficiencies ranging up to 30 per cent, started and stopped readily and kept under efficient loads, the future of electric lighting would be brilliant indeed.

The solution of the problem of obtaining luminous rays unaccompanied by low or invisible heat rays is, to all appearances, yet remote. Perhaps it will come through the chemist and not through the electrician, perhaps from a combination of the efforts of both of them. What nature has done in the various light-giving insects may possibly be imitated by man; the substance secreted by the firefly and oxidized most efficiently for light production may indeed be capable of being cheaply manufactured.

Any one who has had the lesson of the almost deserted streets and avenues of a large city, brilliantly lighted during the small hours of the early morning, brought forcibly home to him, must deplore the necessity for wasting the fuel resources of the world while nearly all the people are asleep. The solution of the problem of light without heat by some electric means would furnish the same illumination at about 1-20th the expenditure of power, and if this were furnished by an engine of 50 per cent fuel efficiency, only 1-100th of the fuel now used would be required. Manual labor may be wastefully used and the new-born generations make good the loss, but the loss of valuable minerals, such as coal, oil and natural gas is a veritable world impoverishment, worse indeed than the terrible destruction of forest timber to be worked up into paper for the many useless prints, such as medicine advertisements, or to be compared with the burying of the beautiful metal, nickel, in the iron of armor plate, never to be recovered and possibly eventually to reach the sea bottom.

We need not dwell here upon the manifest revolution which the electric motor is making for isolated powers located so as to be fed from a central power plant. The past few years have shown a continually increasing use of electric power, and this development will doubtless long continue in an increasing ratio.

The problem of the production of electricity from the potential energy of carbon and oxygen, at high efficiency and in some direct way, is one the solution of which is a hope of the future. The problem is not an easy one to solve, and its solution may not, after all, be direct. It is conceivable that the reducing power of carbon may be employed to rejuvenate exhausted materials such as those from a battery. In other words, the chemical energy of the carbon may be brought into use to prepare other materials for the evolution of electric energy. Even if this could be done at high efficiency and with the use of fuel only, the more direct use of the fuel might cease to be so eagerly sought. We would need for this solution of the problem materials easily recoverable from an exhausted battery and capable of reduction on the large scale by carbon. Other materials reduced in the battery and capable of oxidation by the air at some selected temperature would be needed. We may be permitted to picture the electric station in such case as a huge battery house, coupled with an immense chemical factory. But it may never come.

Electro-chemistry in the coming century has an assured future of great importance. Electro-chemical operations are peculiarly adapted to the utilization of water powers, as they may use the electric energy developed under full load conditions night and day, or may be shut down during periods of water scarcity without much loss. The power of the water may thus replace in its effects those of costly chemical reagents. Moreover, the electro-chemical factory may be run as a means for utilizing surplus energy which would otherwise go to waste in systems of electric lighting or power transmission, where conditions are favorable.

As a matter of pure science, great interest now centres upon the newer ideas in relation to the constitution of the chemical atom, its relation to the ether of space and to other atoms. Faraday perceived clearly that electric and magnetic forces and phenomena were intimately connected with the ether, and subsequently physicists, such as Maxwell, Lord Kelvin and many others, developed the theory from the mathematical side, Maxwell arriving at the conception that light and heat radiation were electromagnetic waves in the ether. This splendid theory received its experimental confirmation in the brilliant researches of Hertz and others following him. What we know of the ether concerns its electric and magnetic behavior. It can be polarized magnetically; it can be stressed electrically; it can be periodically stressed and polarized by atoms of matter and electromagnetic waves such as those of light and heat so set up in it, conveyed at the enormous velocity of nearly 200,000 miles per second, which is the same as the rate of propagation in free ether of the other electrical disturbances. Electromagnetic field or induction and electrostatic induction take place in the ether as the medium. Electric energy is transferred in the ether surrounding a conducting wire, the wire being only the guiding core, so to speak. The ether is an electric medium; its properties are electromagnetic. Has it any other properties? Has it need of any others? It appears to be universal, fundamental. If so, do not its properties and actions lie at the basis of what we call matter? The various chemical elements are related by what is called the periodic law; they are not separate entities created or existing alone; they have been born of conditions. They are probably being formed in some of the distant stars. These are ideas which have suggested themselves from time to time to thinkers for many years past. We know that an electric charge existing anywhere in a perfect insulation cannot be lost, and we know also that an electric current in a perfect conductor is permanent and its magnetic field

permanent. May not the fundamental properties of matter, such as mass, inertia, elasticity, cohesion, gravitation, be in some way dependent upon and explainable by the electric properties of the ether? To these inquiries and others like them much thought is now given by able men.

Chemical affinity may be explained by the electric forces due to atoms possessing electric charges, and it appears probable that electric theories will be found to explain the other fundamental properties mentioned. In fact, ideas of great promise are not wanting in this connection. Prof. R. A. Fessenden, after showing that a relation exists between the velocity of sound and electric conductivity, thus connecting elasticity and density with electric resistivity, proceeded by ingenious methods and experimental researches to find, if possible, the density and elasticity of the ether itself. Recently he has also proposed electric hypotheses for cohesion, inertia and gravitation. These involve such properties as rigidity, momentum, mass and weight. Time and space is wanting to give any proper outline of these extensions of electromagnetic theories, and reference should be made to Prof. Fessenden's papers, some of which have appeared in the columns of this journal.

Briefly, cohesion is explained by the electrostatic attraction of the charged electrons in the atom, inertia is the inductance of the large number of charged corpuscles constituting an atom of matter, and gravitation is due to a density change in the ether around the charged corpuscles or electrons, owing to the electrostatic stresses existing. Upon this theory, as Fessenden points out, the relation between the masses and the weights of various bodies under like conditions is constant for each body. Whether these ideas will stand the test of future research cannot be determined now. That these hypotheses and others of like nature will furnish groundwork for investigation in proof or disproof is unquestionable. It will be noticed that the ideas themselves are based upon the very latest results of physical research.

The recent studies of electrons, or electric charge-carrying corpuscles much smaller than the chemical atom, have formed the needed basis. The advanced physicist has no hesitation in decomposing the hydrogen atom into more than a thousand electrified corpuscles or electrons. Some carry negative charges, others positive. Moreover, the interesting conclusion is reached that the electrons of all the chemical elements are probably of the same size and possibly identical. Beginning with the study of electrolysis as due to free ions in the solution, the conclusion was long ago reached that the action of dissolving a salt in water resulted in partial dissociation and formation of free ions with electric charges. It was found that gases fresh from a flame contained free ions, that they were produced in silent electric discharges, and that air and gases could be ionized in various ways. Ionsare produced by ultra-violet light, by Roentgen rays and by those from uranium or radium, while the cathode rays in a vacuum tube are believed to be due to negatively charged corpuscles. Beginning with the work of Lenard, investigation into the nature and properties of cathode rays has been carried on by many able investigators and with the result of great enrichment of science in the few closing years of the century. Prof. J. J. Thomson has been an indefatigable worker in this field, and his deductions are far reaching. The field itself is a veritable fairyland of science, but the results, however they may be eventually interpreted, are of great importance to future work. If matter be reduced to assemblages of electrons or charged corpuscles, thousands of which make up a single chemical atom, the nature of the charges themselves remains still a great mystery and the real nature of the ether in which they exist remains unsolved. But if the electromagnetic ether theory succeeds in supplanting many unexplained things by a fewer number more evidently fundamental, a real advance into the unknown has certainly been made. Just as a conception of infinite space is not possible with us, so we may only approach without ever reaching the ultimate solution of the mystery of the physical universe. A world without new problems might indeed be a dull one to live in, lacking the stimulus arising from prospective conquest of the unknown.

Franklin's Sagacity.

No part of the writings of Franklin exhibits his sagacity and his power of scientific generalization in a more conspicuous light than his theory of electricity. The talent to discover isolated facts in any branch of science, although possessed by few, is comparatively inferior to that characteristic of mind which leads to the invention of an hypothesis embracing in a few simple propositions whole classes of complete phenomena.—JOSEPH HENRY.

Electrical Theories.

BY PROF. JOHN TROWBRIDGE.

THE professor and the electrician of middle age were taught in their youth—perhaps forty years ago—the two-fluid theory of electricity. This and the one-fluid theory of Franklin were the only ones even mentioned in the text books of that time, while in the standard text books of to-day they are discussed only because of their historical interest. With Calorie and Phlogiston they have been buried in a common grave. No one to-day believes that the electric current can be explained by the movements of two fluids in opposite directions, or by the excess or lack of one fluid. The destruction of the fluid theories is due to Maxwell, who by his great electromagnetic theory of light, showed that light, heat, electricity and magnetism could be ascribed to periodic movements in the ether which differ only in wave lengths. This theory followed the doctrine of the conservation of energy so closely, and proved so rich in possibilities of reasonable explanation of electrical phenomena, that it drove the fluid theories out of the growing literature of electricity, and is the parent of all the theories with which we begin the new century.

The close student of Maxwell's treatise on electricity and magnetism is constantly surprised at the wealth of suggestion contained in that work. He does not treat the subject of periodic currents on metallic conductors, but his general equations need only slight modification to embrace even this subject, and he has laid the foundation of the study of periodic movement in the ether. Hertz's work is entirely based upon Maxwell's equations, and may be considered the experimental illustration of the great Scotchman's theory. It is said that Helmholtz considered that Hertz's great contribution was the micrometer spark gap and the manner of using it to show electrical waves. He, however, who reads Hertz's exhaustive mathematical discussion of his results is lost in admiration of its German thoroughness and scholarship.

The results of Hertz show conclusively that the velocity of electricity in free space is the same as the velocity of light. Forty years ago it was supposed that the velocity of electricity could be measured on telegraph lines, and little was known of the effects of self-induction and of distributed capacity. The theory of Maxwell is constantly receiving accessions of experimental evidence in its favor. One of its fundamental postulates, that of displacement currents in insulators, however, has never been supported in a conclusive manner by experiment. Another postulate, that of the magnetic effect of moving electrical charges, underlies the new electrical theories of the present. This magnetic effect of moving electrical charges is calcu lated by Maxwell in the second volume of his treatise, where he shows that a moving electric charge is equivalent in its effects to an electric current, and Rowland has tested the conclusions of Maxwell by a carefully devised experiment. This experiment was repeated and its results confirmed by Himstet. During the past year Cremieu, a French investigator, has tried the experiment in a novel way and has failed to confirm Maxwell's idea. The Frenchman's methods do not seem above criticism, but the reading of his paper at the meeting of the British Association for the Advancement of Science last August awakened great interest, for the hypothesis of the magnetic effect of moving electrical charges is the keystone of the new electrical theories with which we begin the next century. Several investigators are now busy in the repetition of Rowland's experiment and in the study of Cremieu's methods. If the experiments are shown to be faulty, the two hypotheses, that of displacement currents and of the magnetic effect of moving charges will still hold their place in the electrical theories of the future, until Maxwell's entire theory is overthrown, which seems unlikely to happen. Our experimental methods may be too crude to detect these effects, and we may be compelled to believe in their reality from a cumulation of indirect evidence.

The theory of Maxwell naturally has drawn attention to the hypothesis of the existence of an ether of space, for upon this hypothesis rests our entire conception of the mechanism by means of which electromagnetic waves are sent to this earth from the sun. The Germans, in their recent electrical theories, give a preponderance to the study of wave motions in the ether, while the English appear to have returned to a consideration of molecular motion.

The electrical theory which is now attracting the most attention is that of Prof. J. J. Thomson in regard to the size of the negative ion and to its combination with aggregates of positive atoms. From numerous experiments with the cathode and X rays, he has concluded that the negative ions are much smaller than ordinary atoms. The ionization, therefore, of a gas consists in the separation of the negative ion from the atom. This negative ion is the same for all gases, and its mass is about one-thousandth of the hydrogen atom. Prof. Thomson thinks that this negative ion is the fundamental quantity in terms of which all electrical process can be expressed, for its mass and its charge are invariable and independent of the processes by which electrification is produced, and of the gases from which it is set free. He regards the atom as a collection of bodies which he calls corpuscles. The mass of a corpuscle is the mass of a negative ion in a gas at low pressure, about $3 \times 10 - 26$ grammes. The electrification of a gas is due to the detachment of a corpuscle from some of the atoms. The remainder of the atoms forms the positive atom. Immediately following the papers by J. J. Thomson come very suggestive articles by Drude on what he terms the electron theory of metals. Drude uses the term ion for the combination of electric particles and ponderable masses found in electrolytes, and he calls the particles which probably play a part in metallic conduction electrons or electric nuclei. Every moving electron produces an electric current and establishes magnetic lines of force in the surrounding ether, and therefore all forces which alter the direction or velocity of an electron produce opposing forces, due to a change in the number of magnetic lines of force due to self-induction of the electron. There are bound electrons as well as freely moving electrons. The latter obey the kinetic theory of gases. In order to explain why positive and negative nuclei do not combine to a neutral point, the author refers to the case of a comet which on account of its high kinetic energy does not return to the solar system. Drude's papers on this subject are not yet concluded, but he believes that all galvano and thermomagnetic effects can be explained and calculated by aid of the electron theory. These electrons apparently have their play in the ether surrounding the metallic particles of the conductors, for if the electric charges resided on the metallic molecules it is difficult to understand how the charges could be maintained inside the metallic mass. The theory evidently demands an etheric atmosphere around each molecule of the conductor.

One of the most remarkable of the recent investigations bearing on electrical theories is that of Zeeman, who found that certain spectral lines of gases, when examined in a strong magnetic field, show circular polarization at their edges, and are resolved into doublets and triplets. In studying this effect he found that he had verified the theoretical conclusions of H. A. Lorentz, who, in a remarkable mathematical paper, had proved that the effect studied by Zeeman should take place. Lorentz's reasoning is based upon the fundamental laws of electromagnetism laid down by Maxwell in which it is assumed that an atom carrying an electric charge is not affected in moving along a magnetic line of force, but is very much influenced in directions at right angles to such lines. Lorentz in a late paper enters into a more exhaustive mathematical discussion of the effect predicted by him, which, by a courtesy which is admirable and finds few parallels, he calls the Zeeman effect, he shows that the mechanism of the emission of light on the electromagnetic theory can be much elucidated by a further study of the effects on luminous particles of a magnetic field, and makes the suggestion that a charged sphere, deformable by certain mechanical stresses, could, by changes in electrical distribution, produce the effects observed. To the student of the electromagnetic theory of light, the papers of H. A. Lorentz are perhaps the most suggestive of any that have appeared since Hertz's epoch-making investigations.

The electrical theories, therefore, with which we begin the century are based upon Maxwell's electromagnetic theory. He can be said to have considered vast movements in the ether of space, while we are looking closely into minute actions far beyond the resolving power of the strongest microscope. Still, these infinitesimal actions can be expressed by Maxwell's equations.

The discovery of the Roentgen rays may be said to have led to the new electrical theories which deal so largely with corpuscles and electrons, for these rays exert a remarkable effect on the passage of electricity through rarified gases and upon the accumulation of electrical charges on conductors. It is through the cathode rays and the X rays that Prof. J. J. Thomson has been led to his hypothesis of the electrical ion, which is the smallest entity in the electrical world. This ion is weighed against the hydrogen atom, and the study of hydrogen is therefore of great interest to the electrician and the physical chemist. It perhaps can be maintained that no electrolytic action can take place without the presence of aqueous vapor—that is, of oxygen and hydrogen. It is a question also, whether all chemical actions are not controlled by the presence of this vapor. I believe that I have shown that the various substances introduced into the X-ray tubes to control the degree of rarefaction and therefore to control the production of the rays, act through the liberation of their water of crystallization.

Prof. Dewar has shown that liquid hydrogen is an insulator of electricity, and that an electric spark in it shows the line spectrum of hydrogen. How is the electric current transmitted through the gas? The results of Prof. Dewar certainly show that he cannot claim that it approximates to the character of a metal, and it is difficult to explain the passage of a current by any dissociation or ion theory unless we suppose that the hydrogen contains oxygen.

The electrical theories of the future will be greatly influenced by the growing subject of physical chemistry, which will be principally the study of electrical action between atoms and molecules. I believe, moreover, that we are destined to greatly change our conceptions of the great source of all our electrical energy, the sun. With the aid of very powerful discharges through glass tubes filled with rarefied gases, such as oxygen, nitrogen and hydrogen, all of which gases had been dried with every possible care, I always obtained the spectrum of aqueous vapor. This vapor probably came from the glass walls or from the metallic terminals of the vessels. It seems impossible to conduct experiments in electricity in spaces free from this vapor. It is largely concerned in the phenomena of the production of the X rays. When an X-ray tube is connected to a storage battery of 20,000 cells, at the moment of the liberation of aqueous vapor in the tube there is a powerful manifestation of these rays.

It seems a great step from the study of these comparatively feeble rays to that of the source of all our electrical energy, the sun, yet the contemplation of them tempts one to believe that we shall yet frame a theory of the constitution of the sun which will rest upon electrical laws rather than upon considerations of heat phenomena—that is, light and heat will be merged in the grander generalizations of electromagnetism. Count Rumford, at the beginning of the nineteenth century, left a fund for a medal which is to be given from time to time for notable contributions to the subject of light and heat. In the coming century the committee having charge of the award of this metal of the distinguished founder of the doctrine of the conservation of energy must necessarily include also investigations in electromagnetism. It seems not unlikely, also, that gravitation will fall into line, and that in another hundred years we shall have a reasonable theory which shall connect all of nature's physical agencies in one vast relationship.

Electrical Energy Direct from Carbon.

BY DR. A. E. KENNELLY.

IT is well known that a piece of good coal contains enough energy, when burned with oxygen, to lift its weight against sea-level gravitation a vertical distance of 2000 miles. Otherwise stated, a pound of good coal, when burned in air, liberates about 5.7-hp-hours of energy, or at the rate of 0.175 lb. per horse-power-hour.

The best known means of securing this energy in mechanical form is the heat engine, which is in practice, on a large scale, the steam engine, and in the best steam engines the consumption of coal instead of being one-sixth of a pound per brake horse-power-hour is about 1¼ lbs., while in ordinary fairly large good engines it is between 2 and 3 lbs.

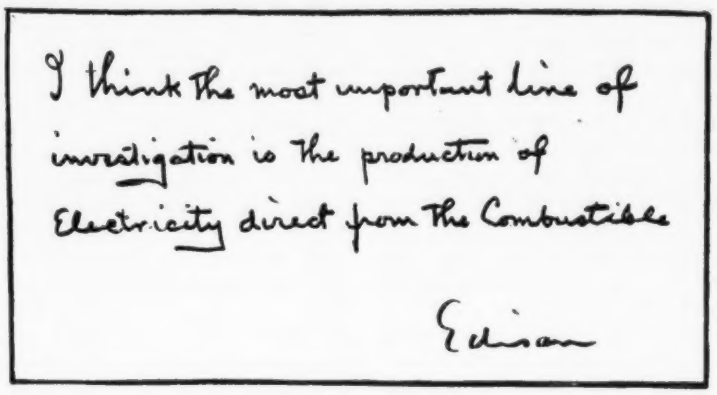
This inefficiency of the steam engine has been known and striven with for many years. The best steam engines of the year 1801 had a net efficiency of about 4 per cent, so that the progress made during the nineteenth century has been to increase the net or total efficiency of the best engines from 4 per cent. to 14 per cent.

The great source of waste in the steam engine is a consequence of the apparently definite law of nature that if we deliver up to any working substance, such as hydrogen gas, a certain quantity of heat, at the temperature say of melting lead, in a heat-tight cylinder from which all thermal waste could be eliminated, and allow the gas to do mechanical work in strokes or cycles by expanding and pushing out a piston, with a subsequent retraction, we cannot obtain the full mechanical equivalent of the heat energy unless the expansion goes

on indefinitely, with a simultaneous depression of the temperature of the expanded gas down to the theoretically absolute zero of -273 degs. C. at which there would be no heat left in it. The ratio of the working range, to the total ideal range of temperature down to absolute zero, represents the thermodynamic efficiency, and the limitations of the heat engine. It would seem that any heat engine or energy-converting apparatus that involves a rejection of heat at a lower temperature must be subject to this limitation and disastrous waste.

The question has therefore often arisen whether the energy cannot be extracted from coal without having recourse to the thermodynamic process, and, therefore, without having to pay such heavy tribute to the absolute temperature of 300 degs. C., or 300 degs. above absolute zero, at which we happen to live, and below which we are unable to carry our expansion.

If, for example, coal were converted into coke, which conversion could be carried on commercially without loss, and perhaps even at a profit, on account of the value of the distillation products; and if the coke could be consumed in a galvanic battery in the same manner that zinc is ordinarily consumed, there would be no such necessary waste of energy, and theoretically almost all of the energy of combination between coke-carbon and oxygen could be liberated in the electrical circuit of the apparatus. This would represent the direct generation of the energy of coke-carbon into electrical energy. Unfortunately, however, carbon refuses to behave like zinc and burn in a voltaic cell. The only known means by which carbon could be made to give out its energy in a voltaic cell, in competition with the use of coal in the steam engine, is by the formation of either carbon monoxide or carbon dioxide; in other words, the same oxidization which yields the energy of carbon in the process of combustion must take place electro-chemically. The oxygen for this purpose must be obtained from some cheap electrolyte containing oxygen, and cannot, so far as is known, be obtained from the atmosphere directly. In other words, it is necessary to rob an electrolyte of oxygen in order that the carbon shall combine with it electrolytically. If the oxygen of the electrolyte were but feebly held, that is to say, if the electrolyte consisted of a chemical combination with oxygen so unstable as to require but a negligibly small amount of energy to tear the oxygen away, and if, moreover, the substance or substances with which the oxygen was unstably linked were capable of entering into combination with the other plate of the voltaic couple, with but little absorption of energy; then it might be possible for the voltaic cell to work with a power output theoretically approaching that of the combustion value of carbon and oxygen. The union of carbon and oxygen in the cell would take place without sensible elevation of temperature, the electrolyte would give up its oxygen for the formation of carbon dioxide, and the products of the cell would have to be chemically eliminated in some continuous manner, to be replaced by fresh electrolyte. All this requires the existence of an electrolyte possessing the properties of small chemical stability, together with the capability of forming suitable chemical combinations at both plates of the couple. Moreover, the electrolyte must be so abundant as to be very cheap.



EDISON: JANUARY 1, 1901.

Unfortunately all the electrolytes that are abundant are very stable combinations, which require a large amount of energy to tear the oxygen away from them, and if, as commonly happens, the energy required to abstract their oxygen is greater than the energy which carbon will yield on combining with their oxygen, it is evident that the voltaic cell so constituted would not work. The amount of energy which is necessary for the chemical disunion of oxygen from all the ordinary electrolytes is fairly well known by thermo-chemical measurements. An examination of thermo-chemical data confirms the results of the very large amount of experimental enquiry made during the past century, and leads to the conclusion that there is no cheap electrolyte available for the burning of carbon in a voltaic cell, at ordinary temperatures, with an efficiency that can compete with the steam engine. Apparently nothing short of an epoch-making discovery can help us in this direction.

Turning now to the voltaic cell worked at high temperatures, instead of at ordinary temperatures, although the prospects from thermo-chemical data seem equally unfavorable, yet there is some hope of success in this direction, if only from the fact that there is less experimental knowledge of hot voltaic cells than of cold voltaic cells, and there is always hope so long as any reasonably available combination has been left untested. The electrolyte would now be a fused salt instead of a solution, and must give up oxygen to the carbon for the production of carbon monoxide or dioxide. The remaining constituents of the electrolyte must be suitably provided for, and eliminated at the opposite plate, without serious loss of energy.

The hot voltaic cell is complicated to some extent by the introduction of thermo-electric phenomena, which inevitably accompany the contacts of dissimilar materials at markedly different temperatures. If the cell is a mere thermo-electric couple, it must do work in the circuit by receiving heat, at a high temperature, at one contact, and rejecting heat, at a lower temperature, at another contact, thereby coming under the thermodynamic law of temperature limitation, just as does a heat engine, besides being subject to additional limitations imposed by purely thermo-electric conditions. Consequently, not only is the thermo-electric method of obtaining energy from carbon, by allowing its combustion heat to operate thermo-electric couples, likely to be a failure in competition with the steam engine, owing to the temperature range limitation, but any real voltaic action in which carbon is oxidized in a hot electrolyte can succeed only in spite of, and not by reason of its accompanying thermo-electric actions.

In other words, it would seem that a hot voltaic cell can only be a successful competitor with the steam engine on account of its voltaic action, and such thermo-electric actions as inevitably occur therein must be wasteful for the same reason that the steam engine is wasteful; namely, because the temperature range, instead of being between the high temperature and absolute zero of temperature, is actually between the high temperature and a convenient moderate temperature. While, therefore, the prospects are not encouraging for the production of a hot voltaic cell-burning carbon, yet there is hope that it may be found, whereas, with the cool voltaic cell, the case seems to be almost hopeless for the near future.

If the energy of burning carbon with oxygen cannot be liberated electrically in a direct manner, as above outlined, yet it may be possible to use its chemical potential energy to perform purely chemical change in other combinations, and use the resulting products of that chemical change for the final development of electrical energy in the circuit of voltaic cells. Such exchanges of chemical energy at high temperatures are not subject to the thermo-dynamic law of temperatures, although incidentally much heat energy is usually wasted by the furnaces in which such substitution takes place. Theoretically, the exchange of chemical energy from carbon to some other substance in this manner does not necessarily require a wasteful expenditure of heat, and it is conceivable that the furnaces in which the exchange occurs might be made so nearly heat-tight, by gradual improvement, as to waste but little energy.

Such indirect processes of obtaining energy from carbon are already in use and are illustrated in the ordinary voltaic cell burning zinc. The zinc is originally taken in the form of oxide, and heated in a closed furnace with carbon; the energy necessary to tear the oxygen from the zinc, or reduce the metallic oxide to the metal, is supplied by the energy of combustion of carbon with the oxygen, and if the retort could be made heat-tight, and the waste of heat in raising the temperature of the active substance prevented, the energy of carbon would be transferred to the zinc in a fairly considerable proportion. Owing, however, to the fact that in practice very considerable thermal waste does occur, the metallic zinc, when prepared for the voltaic cell, carries but a very small fraction, usually less than 1 per cent of the energy originally possessed by the carbon used in the process. Moreover, the labor involved in the operation of exchanging the energy between the carbon and the zinc increases the expense. The result is, therefore, as is well known, that the voltaic

battery employing zinc cannot possibly compete with the steam engine as a developer of power.

In this indirect method of transferring the combustion energy of carbon to some substance capable of use in a voltaic combination, there is probably much more hope of exceeding the efficiency of the steam engine, than in obtaining the energy by a direct voltaic method, if only for the reason that the experimental field is so much more extensive. If, however, a substance or combination of substances were found in which, with the aid of carbon, combustion energy in an improved voltaic cell could be developed so as to attain a final efficiency exceeding that of the steam engine, it might readily happen that the cost of the labor involved in the supply of the active substance and in conducting the process might be prohibitively great, so that unless the substance were very cheap and the process of energy exchange and subsequent voltaic release very simple, no commercial realization could be expected.

There are consequently two broad avenues in which improvement may be looked for in utilizing the energy of coal. One is by improving the heat engine, and the other is by finding a suitable substance to burn in the voltaic cell, either hot or cold, transferring the chemical energy of carbon to that substance by purely chemical means in a retort as nearly heat-tight as possible.

So far as the heat engine is concerned, it is reasonable to expect improvement in the apparatus whereby the energy thermodynamically convertible may be better conserved, or the efficiency of the machine improved, when debited with all the energy that its temperature range will permit of being converted from heat into mass motion. But with the modern steam engine, if these wastes were entirely prevented, the efficiency would still be only about 20 per cent, and the real difficulty lies in the range of working temperatures. What is needed is a greater range of temperature, a lower temperature of the condenser, and a higher initial temperature of the working substance, the latter requirement being much the more important of the two. In the case of the steam engine, this means higher steam pressure, and improvements during the past century have been steadily made in this direction. A greater difference of temperature in one and the same engine, however, tends to increase the thermal waste by leakage conduction from the hot parts to the cool, and so to diminish the relative actual efficiency. This has been, to some extent, overcome by coupling three or four seperate engines to one common driving shaft and expending the steam successively in the successive engines, thus producing the multiple-expansion, compound engine. The limits of temperature and pressure elevation seem to be almost reached for the present in this direction, partly owing to the increased difficulties in lubrication at high temperatures.

In the gas engine, however, the initial temperatures are considerably higher, and for this reason the thermodynamic efficiency of gas engines attains nearly 30 per cent or is considerably above that of the steam engine. All that can be said for the future of heat engines is that any marked improvements in their efficiency must come from an increased range between the limits of the initial and final temperatures, whether this be effected in one engine, or in a plurality of associated engines. Improvement in lesser degree may, of course, be expected from the diminution of heat wastes in boiler and engine, as well as in the reduction of mechanical friction. The steam-turbine principle, if successfully adapted to large sizes of engines, would introduce a great simplification of parts, reduction of weight, with, perhaps, some diminution of these losses. But the steam turbine must be as much limited by the temperature range, as the ordinary reciprocating heat engine.

Apart from the solution of the problem by improvements in heat engines, or by the discovery of a suitable working substance in the voltaic cell, there is always the possibility of finding some new mechanism by which the heat energy of carbon atoms can be converted into the energy of mass motion. We are still so profoundly ignorant of how the energy of carbon is stored relatively to that of oxygen, that a discovery of the hidden mechanism of the storage principle might lead to a discovery of a new means of releasing it. In other words, there is something in a lump of carbon in conjunction with a lump of oxygen, which corresponds either to a bent spring or to the motion of the gyrostat. All we know is that when the two substances are brought into sufficiently intimate contact, with the aid of a high temperature, either the spring is released, or the gyrostatic motion is arrested, with the production of jostle-energy among the molecules of the substance, or of that particular kind of rapid oscillatory molecular motion which we assume heat to be. It is conceivable that if we had a clearer idea of the nature of the invisible springs, or invisible gyrostats, we might discover some means by which the springs might be released or the gyrostats arrested, without the production of jostle-energy, and with the direct production of some kind of utilizable force.

The mere fact that by chemical processes we are able to transfer at least a part of the energy of carbon to a different substance in chemical form, without first liberating it in heat, should encourage the hope that we may find a means of transferring it in some form other than chemical or thermal, and not until we have a clear knowledge of the mechanism involved, and a clear conception of its neces sary limitations, will that hope be destroyed. When we consider that the world's annual consumption of coal is roughly 500,000,000 of tons, the enormous importance of improving upon the means of obtaining the energy from coal is sufficiently apparent. Perhaps the most important ultimately, of all problems before the human race, is the discovery of an available power supply when the world's coal shall have become exhausted some hundreds of years hence. Every waste of this substance, diminishes to that extent the time in which the problem must be solved, if the future of the race is to be unchecked. Meanwhile, however, there is every reason to expect that improvements will take place in heat-engines, and there is reason to hope that if their improvement is not sufficiently rapid, a more efficient means of utilizing the energy may be found either indirectly in a voltaic cell, or in some manner not at present conceived of.

Light without Heat.

BY PROF. R. A. FESSENDEN.

APPARENTLY the most self-suggesting way of getting light without heat would have been to have developed eyes which could see all the rays. But with an extremely aggravating indifference to the waste of grey matter thereby to be entailed upon their descendants, flabby one and backboned one went placidly along, developing eyes which would only respond to a quite limited range of vibrations. And if this apparent lack of business foresight had been pointed out to any particular specimen of wiggling iniquity, he might possibly have replied, "Do not tinker with development. In years to come, one with a backbone will call your attention to the fact that, 'in the long run, the will of the people is, for the people, better than that of the wisest individual. If we developed such eyes for you, they would not be of use, for what you saw with heat rays would be blurred, and ultra violet rays don't go very far. And besides, as regards X-rays, with the morality of the community in such a rudimentary state, I have serious objections to my neighbors being able to see when I have anything extra good to eat inside me. Consider our economical friend, the firefly, who serenely oblivious of the meterman's threats to turn off the gas, titillates at will his abdomen up to any desired candle-power, and go and do likewise."

But we have been a long time trying to do likewise.

How much the sky meant to our predecessors, we can never know. Sometimes a long stretch of camp life goes far to give one a faint conception and to make him realize, that as we have extended our knowledge, we have contracted our firmament. No one now looks up, and we have forgotten the array of the stars.

From resinous knot to the flame of burning oil cannot have been a far step, but for more than forty centuries (how much longer we do not know) we rested at this stage. And it is a wonderful thing to contemplate, that the generation now passing has been the first, since the world began, to be able to neglect the waxing and the waning of the moon. And since gas itself is merely a light hydro-carbon, of the same general nature as that used for lamps and candles, being thus rather an improvement in the means of distributing the material than a new method of lighting, we may say that it is only within the last twenty-five years that new methods of lighting have come into use.

These may be divided into the following classes, (not fundamentally, but merely for the purpose of dealing with them.)

First—Light produced by heat.

Second—Light produced by heat combined with chemical action.

Three—Light produced by chemical action.

To consider the advances already made, and which we may expect to be made in the first of these.

The evolution of the incandescent lamp was a labor so tremendous that no one man could have accomplished it. The method of obtaining a light by heating a wire or rod by the electric current was long

unsuccessful. Then Crookes invented his methods of producing high vacua, and the method of leading in current through glass by means of pieces of platinum wire sealed into it. Sawyer showed that carbon, especially that produced from organic matter of a fibrous nature, was the best material for the filament. Then Maxim introduced the flashing process, and the incandescent lamp, *as a lamp*, was complete. It still was not, however, a commercial success, for the alternating current transformer not having been then perfected, there was no available means of using the lamps; they required too much copper in the mains, prohibitive in price, or else had to be worked in series, which led to other difficulties. But in the meantime Edison had discovered the correct principle of distribution, *i. e.*, to make lamps of high resistance and burn them in parallel. His filaments were at first made of metal wires, and in a number of public interviews, he stated that Sawyer, in using carbon, was on the wrong track. But the metal-wire lamp proved a failure, and incandescent lighting was finally brought to a practical form by a combination of the Crookes-Sawyer lamp and the Edison principle of distribution.

Since that time advance has been slow. The general adoption of Maxim's flashing process has considerably increased the life and efficiency, and the cost of manufacture has been greatly reduced, by systematized methods, the use of very fine platinum terminals, and, lately, by the adoption of my suggestion of using phosphorus vapor in exhausting the bulbs.

As to improvements to be expected in this line, one would be the use of much larger bulbs. The present bulb is absurdly small, and I have experimentally found that much better life and candle power can be obtained with large bulbs. It was for this reason that I suggested large-bulbed incandescent lamps as secondary standards, in the Standards of Light and Illumination Committee of 1893-4. It remains for some manufacturer to ascertain with what size of bulb the increase of cost of glass overbalances the gain in efficiency and life.

Another possible point of improvement would be the combination (not mixture) of the carbon filament with some substance which would give it a more decided emission band spectrum. Nichols has shown that carbon does not radiate as a purely black body, but has a maximum in the yellow. This is very fortunate. But possibly this maximum might be increased, by the addition of a slight amount of some other substance, (I say slight,) just as in color photography we change the position of the maximum absorbtion band by adding traces of dye stuffs. Suppose we make up, for example, a thio-cellulose, and then substitute in that compound traces of iron, or suppose we flash in an iron compound of gasoline. Theoretically there should not be any insuperable difficulty in manufacturing a compound of carbon, which should be nearly pure graphite, but yet have a strongly marked emission band.

It must, however, be a compound, and not simply a mixture. Simple mixtures, hundreds of which have been tried and patented, will be of no use, and, a priori, one would expect that the percentage of added substance should not exceed, at most, 1 or 2 per cent.

The coating of filaments with the rare earths cannot, I believe, yield any permanent increase of efficiency, for reasons given later. In 1891 I made a number of experiments for Mr. W. Stanley, at Pittsfield, coating filaments with Welsbach materials, but found, on making photometric and energy measurements, that there was no appreciable gain.

If we examine the spectrum of a black body, we find it something like this,

with a hump in the middle, and the position of this hump, and its size, varies with the temperature. Formulæ connecting the radiation with the temperature have been given by Stephan, Boltzmann, Wien, Planck, Rayleigh and others. Of course we cannot get an absolutely black body, but Kirchoff has shown that if we coat the interior of a sphere with any approximately black substance then the radiation from any small hole cut in the sphere will be of very nearly that of the ideally black body. Wien has extended this theory. If, however, the body be not spherical, but cylindrical, say, and the hole be not small, this will not be true. Theoretically the number of internal reflections, before passing out, must, for any given wave length, vary inversely as the absorption, so that if there is no absorption there is no ideally black emission. But practically all bodies have some absorption, so that by making the hole small enough, the rule holds. The rule, however, fails if there is any emission elsewhere than through the small hole, so that a thin tube with a hole cut in it would not obey the law even approximately, unless the hole was extremely small, or the absorption very great.

Both theory and experiment show that as we increase the temperature, the emission of any visible wave length of such a body increases. Consequently we must get as high a temperature as possible, within limits, for our incandescent lamp.

But carbon cannot be raised above a certain temperature. Consequently inventors have been seeking other substances. Many years ago Le Roux heated magnesia and similar materials, and then kept them at incandescence by passing a current through them. Later Jablochkoff used such rods, which he heated, either by passing high potential sparks over them, or else by heating them in a flame, or by coating them with a film of carbon. Other experimenters made similar lamps, heated by an arc, and one of these came into practical use for a time In 1890 I made some lamps by heating glass and passing a high potential current through it, giving a brightly incandescent ribbon of light in the glass, but they did not last, and the glass became opaque, presumably through electrolysis, and very brittle. Quite recently Nernst has revived the Le Roux lamp, heating it, however, in a slightly different method, *i. e.*, by radiation from an electrically-heated wire. This, however, has not yet been made a success, as the rods take too long to heat, and has been largely abandoned in favor of Le Roux's original method, but I have seen lamps of the Le Roux type which, lit by another method, worked practically instantaneously, *i. e.*, in but little over a second, and there is no doubt but that in a few years the Le Roux-Jablochkoff lamp will come into practical use. This, for two reasons—first that they permit of higher voltages, and hence more economical current distribution, and secondly, that owing to their much higher temperature, they are considerably more efficient. Still another type of Le Roux lamp, lit by smearing a thin film of some conducting substance, usually a grease-like compound of one of the rare earths, across the terminals, which gives off, on the current passing, a minute trace of pure water and vapor and carbonic oxide, and leaves a very thin film of the rare earth which acts to renew the surface of the pencil, has been tried with good results, and as it gives some light instantaneously, may possibly have a future. In any case, the Le Roux lamp has probably come to stay, and any remaining difficulties will no doubt be overcome soon, and our next most important advance in incandescent lighting will probably be in this direction.

The arc lamp may possibly be considered a pure heat lamp, for though there is some increase of luminosity when burning in air, yet this may not be due to chemical action, (except, of course, where the carbon is actually *burnt* in the air,) but to the effect of the presence of air on the passage of the current. Its temperature is apparently that of the vaporization of carbon, hence its efficiency is very high, but it varies somewhat with the carbon and has hence been found unsuitable for photometric standards. Practically very little advance has been made in this as a light producer, and in fact many of the old Thomson-Houston and Brush machines were running quite recently, and some are working even now. But the enclosed arc lamp, though much inferior as regards efficiency, is rapidly supplanting the old type, on account of its saving in cost of trimming and carbons, to be itself probably supplanted by the Le Roux lamp. Little or no further advance is to be expected in this direction, unless possibly (and indeed this is a rather promising field) by combining the carbons, as suggested in the case of incandescent lamps, with a small percentage of substance which will give a better emission spectrum. This is more promising, because the light of the arc is already too blue, whilst that of the incandescent lamp is too red, and it has been found easier to produce a low band in the spectrum than a high one.

Many experiments have been made on admixtures of substances, aside from combinations, with the carbons. Magnesia, for example, would be very beneficial, and has already been tried, but apparently the fact has not been appreciated that not all kinds of magnesia will do, as it is only when freshly prepared in a proper manner, that this substance has its great light-producing power. It, and similar solid substances are, however, barred, as the enclosed arc will be probably become the universal type, and such substances would cloud the globe.

Of vacuum tube lamps, many have been suggested. It must be nearly thirty years ago that the first attempt was made to light a mine with vacuum tubes and induction coils. Since then we have had many types, as, for example, Crookes' cathode bombardment lamp, and others which, surrounded by a cloud of non-luminous verbosity, have not done much actual illuminating. The only approach to success, of which the writer is aware, is the admirable work of Macfarlane. I know of no reason why his lamp should not ultimately prove

a success for certain classes of work, where very long tubes and high potentials are not objectionable. In 1890 I made measurements on the efficiency of vacuum tube illumination, by passing the current a certain time, measuring the candle power of the tube, due to the light from the gas, and then dropping the whole tube into water. (I was fonder of glass blowing then than I am now.) From the energy put in, (for an ammeter I used a hot wire voltmeter, with silver instead of platinum; this is a good instrument for such work) the heating of the water, and the candle power, the efficiency was determined. It came out quite high, slightly less than 1 watt per candle-power. Most of the loss was found to be in the heating of the anode and cathode, and this it was attempted to overcome in two ways. First, by lengthening the tube, which gave good results, though not commercial, and secondly by making the gas itself the secondary of a transformer. This failed because of too great hysteresis loss in the iron, though one type was not so unpromising.

One trouble with such lamps has been the fact that in most cases they gave a line spectrum. Again, in many cases, where the spectrum was not line, but more or less banded or continuous, the character changed, after running for a time, to a line one. The cause of this is probably that connected with the theory suggested by J. J. Thomson to account for the continuous spectrum of his oxygen tubes, i. e., polymerization, the ability to polymerize being lost on continued heating. It is possible that some of the new gases would work much better in a Macfarlane tube. Helium, for example, at ordinary temperatures, will carry a spark about 30 times as far as air, but unfortunately is little, if any, better than lower pressures. I have sometimes thought that possibly an exact determination of the spectrum of the aurora and a subsequent search for the gas, if it is a gas, and not ice crystals, (improbable, though,) concerned in this phenomenon, in the results of the fractionization of liquid air might lead to a possibly valuable discovery. But, promising as the vacuum-tube lamp may be, it is probably not to be developed by any one man, however industrious, and as in the case of Crookes and the incandescent lamp, must wait for results obtained by workers along quite other lines.

Among combination, chemical and heat sources of illumination we may place the Welsbach lamp, acetylene and the magnesium lamp. This classification may be objected to. But I make use of it because, though there is no need of assuming, for example, in the Welsbach lamp, any peculiar catalytic action, the heat being sufficient, (even an ordinary candle flame is hot enough to melt platinum, in fine wire,) yet, as Nichols has shown, all such light-giving compounds, as zinc, oxide, magnesia, etc., fall off rapidly in their luminous emissive powers, and from this there seems to be but little doubt but that there is some chemical change taking place, and that, for instance, when magnesium wire is burnt, the greater part of the light is due to some change in the formation of the magnesia, for most kinds of magnesia have a different spectrum and do not give out so much light.

The magnesium lamp is at once barred out by reason of the solid products of its combustion. Acetylene is better, but I doubt if it has come to stay as an illuminant, though no doubt it will be used for some time in small towns. The Welsbach has now been so improved that its light is by no means disagreeable, and it is highly efficient. Unless important improvements are made in electric illumination in the near future, I look to see Welsbach lights, fed by fuel gas, this same gas piped into the houses for heating, largely supplant electric light and every other means of illumination in all cases *where economy is the prime consideration.* Were large fuel gas companies to be formed, its advantages, *i. e.*, only one set of pipes for fuel and light, and its extremely low cost, would be bound to drive everything else out of the field. And this is a danger which it is not at all unlikely the electrical companies will soon have to face, for the cheap production of fuel gas from bituminous coal cannot be many years in reaching a commercial development.

So far, no signs of light without heat, unless by the production of the absorbtion bands mentioned above. But coming now to chemical methods, is it not here that we must find the solution of our problem? Why should we electricians expect to be the light producers of the world? Must we not ultimately take as our proper sphere the production and transmission of energy for its various uses? This seems to be our natural field.

Though a few experiments had been made along this line, I never thoroughly realized the possibilities in this direction till my attention was called to them by Prof. Elihu Thomson. It was while discussing the present subject that he pointed out to me the fact that certain aldehydes could be oxidized at low temperatures, with luminous phenomena accompanying the process. This he considered a promising field, and his idea is certainly worthy of the very closest attention.

Is it not in this direction that we must look for a solution of our problem? Since, according to the instructions I have received from our ever-esteemed editor, I am at a certain point to cloak myself with the mantle of the seer and to exercise a merely nominal suzerainty over my prophetic pen, let me obey at this point.

Can we imagine some worker, equipped with a prism spectroscope of great dispersion and still greater light-gathering power, himself a good organic chemist, to take up the work. He begins by taking photographs, after exposures possibly days long,. (for here we have no diffusion from the sky to limit our time,) of the scores of light-producing organisms, fireflies, glow worms, phosphorescent wood, etc. He determines the flutings of the emission bands and makes volumetric measurements of efficiency. He determines the effects of different gases, when combined with the light-producing matter, and notes how the bands are shifted. Possibly by observations on the Fiévez effect (obtained with great difficulty) he determines the approximate mass of the corpuscular groupings involved. Finally, from similar researches on the oxidation of inorganic substances, he finds that all such phenomena as, for example, the rusting of iron, the oxidation of magnesium, the oxidation of sugars to alcohol or vinegar, are accompanied by emission bands. By combination of other substances he finds out how to raise or lower the position of these bands so as to place them in the most efficient position of the spectrum. Finally he presents us with a crystal globe, which, hung from the ceiling, by the slow circulation of air through it, controlled by a valve at its lower end, becomes luminous to any desired extent and fills the room with a pleasant and stimulating perfume. And with slight changes of composition the materials in these softly-glowing globes are made to give us all the colors of the rainbow, or, thrown as dust far up into the air, to make a falling splendor such as we cannot now conceive.

The Steam Engine of To-Day

IN THE FIELD OF ELECTRICAL ENGINEERING PRACTICE.

BY DR. R. H. THURSTON.

A "HISTORY of the Steam Engine," added to the International Series about a quarter of a century ago having attracted some attention, its author, the writer, was asked by the editor and founder of the then new periodical *The Electrical Engineer,* 1882, to furnish its readers with a summary of the principal features of the stationary engine of the time, especially as adaptable, or actually employed, for the special work of the electrical engineer in power and light distribution. In the series of articles running through the year 1883 which was prepared in response to that request, the endeavor was made to exhibit the evolution of the modern engine from its earliest beginnings, and especially, in its later stages, those forms of development which were particularly necessary to fit it for the impulsion of high-speed machinery like the dynamos then usually constructed. At the time, however, the distribution of power by the electric wire had hardly begun and the work of practitioners was substantially all in the department of electric lighting; the dynamo was usually of the bipolar type and its speed of revolution necessarily high. The day of large powers, for street railway purposes, and of the multipolar direct-connected dynamo had not then arrived, although it was just about to appear and the writer was even then gathering plans of direct-connected engines which were beginning to be built abroad, and especially in Germany. Those articles were later published in book-form, with accessions in successive editions, by the Messrs. Wiley.*

The editors of the ELECTRICAL WORLD AND ENGINEER, at the beginning of another quarter century, at the opening of the twentieth century, desire a statement of the progress in this field during the later period of development of prime movers for the dynamo-electric machinery of the day, exhibiting the modifications of construction and the economic applications which have marked the adaptation of the steam engine to the most recent developments of this now enormous and important as well as magnificently impressive industry. The earlier articles were intended to give a consistent, chronological and philosophical account of one of the most interesting scientific and mechanical evolutions that the world has seen, and one pregnant with a larger influence upon the world's progress than any other product of the inventive power and constructive talent of the race—one which has effected a greater advance in material civilization, and in all that is dependent upon progress in civilization, during a single century than had been observed in all preceding time. The present article has far less scope and can only briefly study and

* Stationary Steam Engines; N. Y., Wiley & Sons; Lond., Chapman & Hall.

describe the culmination of that mighty progress as illustrated during the later years of the nineteenth century.

Hero, or some older Greek mechanician, a hundred years and more before the Christian era, invented a steam turbine and a "steam fountain" and showed his contemporaries numerous applications of the powers of heat-energy and of the heat motors in crude forms. Then the world of mechanics stood still, or nearly so, for centuries. In 1600 to 1629, revivals of Hero's apparatus occurred, and, in the latter year, Branca invented, or at least published, a new form of steam turbine. Hero described the "reaction wheel," Branca the "impact turbine" actuated by steam. During that century the Marquis of Worcester and Captain Savery perfected Hero's steam fountain sufficiently to make it practically available for its primary work, the raising of water; but the opening of the seventeenth century saw the introduction of a new type and the evolution of the steam fountain practically ceased.*

Newcomen and Calley, in 1707, invented the steam engine, the train of mechanism familiar to engineers of the nineteenth century; the system of mechanisms consisting of a steam cylinder and piston converting the stored heat-energy of steam into useful mechanical energy and work and applying that energy and work to its appointed purpose through a distinct mechanism, a pump with its cylinder and piston or plunger, also completely differentiated from the driving mechanisms. They were the inventors of the steam engine as we know it, in the essential features and principles of construction which constitute it a distinct type, and Watt was the great refiner and improver—not the inventor of the modern steam engine, as he is usually thought to be by the popular mind and asserted to be by his biographers. Newcomen's engine exhibited the distinctive and fundamentally primary elements of the modern construction, and, as improved by Watt, it became suitable to do all the work of the world just as soon as he had brought it to the point of turning a shaft. The commencement of the nineteenth century found the modern world mover ready for any duty falling to it to perform; the inventors of the century found their task one of simple adaptation to specific and special tasks, or the improvement of the details of construction in such a manner as to secure a closer approximation of the real to the ideal heat motor. Thus, Sickles invented his detachable valve gear; Corliss and Greene and Wright and others modified it in such a manner as to permit the steam distribution to be made practically perfect, as illustrated by the indicator diagram; Porter and his companion genius, Allen, devised constructions making it capable of retaining the virtues of the contemporary low-speed engine while driving its shaft at a speed of 200 revolutions a minute and more; Stephenson fitted the machine to the locomotive; Fitch and Stevens and Fulton adapted it to steam navigation; Armington and Sims and their many successors redesigned it for use with the dynamo; Westinghouse and Willans brought out peculiar and original and valuable types for a similar purpose, as well as for general employment, and our own time has seen a great forward movement in the successful endeavor of our inventors and designers to meet the demand of the day for power on an enormously large scale, including adaptation of the engine to driving correspondingly immense dynamos of the multipolar type by special constructions of engine in units of several thousands of horse-power capacity each, grouped in single stations supplying 50,000 and 75,000 horse-power to hundreds of miles of street railway and operating half as many thousands of cars, employing current generated at as high as 6600 volts pressure and transmitted at 20,000 from generators of 3500 to 37000 kilowatts capacity at the former tension, and with a periodicity as low as 25 per second.

Meantime the scientific side of the engineer's problem has not been neglected. The progress of the development of what Hirn called the experimental theory of the steam engine has been important, but more in its application than in great results of experimental research. Numberless exact determinations of the quantity and rate of flow of the energies through the machine have been made by skilled investigators and in every field of employment of the motor; the chart of the steam from the boiler to and through the machine to the point of delivery has been laid down in admirable form by Sankey and our scientifically trained and carefully drilled graduates of the engineering colleges are constantly adapting their scientific learning and their laboratory methods to the purposes of the designing and constructing engineers, seeking guidance toward the goal pointed out a hundred years ago by James Watt, and are supplying new expressions for thermodynamic and thermal and dynamic law, and constants for the equations of energy, utilized and wasted, as dealt with in the heat motors and especially in the steam engine.

The limitations obstructing the application, literally and completely, of the principles of scientific theory in the design of the machine are now well recognized and to-day even the fundamental fact is admitted that the nature of the problem compels the engineer to subordinate everything in design and construction to the demands of the treasury and that the problem is, almost invariably: How shall the machine be designed, constructed and operated in order that the required quantity of power shall be delivered, continuously and with certainty, at minimum cost as shown in all the accounts on the treasurer's books? It is the acceptance of this latter principle by the engineer that marks the completion of his theory of the problem.

The practical corollary of this proposition is thus simple. It asserts that among costs of production of power is to be recognized, in its proper proportion and distribution, the capital account and its current fluctuations, principal and interest. This infers that every waste of energy and of capital—which is, in fact, energy, potential energy, stored energy—is to be studied and reduction of waste is to be effected down to a limit at which the costs of further reduction will be greater, in sum of all accounts, than the additional saving; while increased efficiency is to be secured in every direction possible up to a limit at which the further gain is compensated by equal added cost. It has come to be recognized that the older method of constructing specifications, which called for a certain maximum practicable "duty" of engine and minimum practicable consumption of fuel, was wrong and often the source of enormously costly financial errors; the true system being that which specifies that the stipulated amount of power shall be supplied at a certain minimum cost per unit, on *all* accounts, capital, running expense, insurance and all other accounts aggregating on the treasurer's books and chargeable to that power account. It is now known and is recognized by all intelligent and well-informed engineers, whether designing, constructing, purchasing or operating motors, that concentration of power into small space, weight and costs, is the task set for all, and that the ultimate gauge of success is the outgo on all accounts per unit of power supplied. This has made the compound engine standard where otherwise the triple-expansion machine would have been adopted, and has dictated smaller cylinders and lower ratios of total expansion, often very much reduced, as compared with the proportions derived by a study of the duty problem alone. It is seen that it often happens that we cannot afford to pay for increased efficiencies and economies of fuel consumption, whether at engine or boiler. Exact methods are familiar to the well-informed engineer which enable him to determine precisely what proportions of boiler and what type and size of engine he can best adopt in solution of the financial problem under specified conditions and in stated localities, the market being known. The interests of the client, not the inclinations of the designer, have come to be studied and secured; or, rather, the purpose of the engineer is identical in source with the best interests of his client. Rivalry in increasing "duties" of *fuel* is coming to be superseded by rivalry in seeking increased "duties" of *capital*.

Finally, the new century opens with some indications that we may be about to see, in some directions at least, a tendency to what the biologist calls "atavism," a recurrence to earlier types, and, in this case, with a possible permanent change in the line of progress of the last century. The steam turbine, the toy of early centuries and never before seriously entering the field, is revived, and with its absolute limit in simplicity and low cost of construction and its closest approximation to the thermodynamic ideal, it seems likely to find place in the market, even if it does not ultimately, as perfection proceeds, permanently displace some forms of standard heat motors of our time. It is suited for use with any possible steam pressure that our boilers can supply; it can usefully employ as highly superheated steam as our materials of construction can bear; it is a motor of maximum thermodynamic efficiency and of already high actual economy of both fuel and funds, and, once the difficulties coming of its necessarily high speed of rotation, as now constructed, can be overcome, its extensive employment with corresponding displacement of its comparatively enormously complicated and costly rival, the reciprocating engine, is assured. It offers us one of the most seductive problems of the new century.

In practice, the steam boiler has come to be in increasing proportion a water-tube steam generator, partly on the always familiar

* The steam fountain was later improved by Hall and, under the designation of the "pulsometer," is still doing an important work where simplicity of construction and portability are more important than economy in operation.

ground of safety against disastrous explosions, largely of late because of the greater ease with which it can be adapted to the requirements of modern high-pressure practice. It is now supplied without hesitation for a pressure of 225 pounds by gauge, and can be furnished as a special construction for much higher tensions. A pressure of 175 pounds per square inch by gauge may be to-day considered as well accepted a standard for advanced construction as was 125 lbs. 25 years ago, or as was 50 lbs. at the middle of the century, and 10 or 15 lbs. at its beginning. It is to-day a steel boiler; and here, as in all other departments of engineering, iron is coming to be a rejected material and seems likely ere long to become unknown.

Superheating is once more coming into use, the adoption of high-temperature mineral oils for cylinder lubrication doing away with the difficulties of utilization of moderate degrees of superheat in the engine, and various constructions of superheater proving comparatively satisfactory at the boiler. Something still remains to be accomplished to insure safety and durability in this apparatus; but in Europe, where superheating has persisted continuously from earlier days, and in the United States and Great Britain, where it has for many years been almost unknown, alike, success seems promised soon, if not already attained, in this essential element of economical steam-engine operation. This practice has probably returned to stay with us.

There have been no important changes in general practice and design in the construction of valve gearing. The Corliss and other earlier devices appear to meet all requirements. The only changes of late have been in the adaptation of certain types, old in themselves, but new in this field, to this line of power development. Thus, the vertical marine type of engine has secured a footing in electric light and power station work, and, provided with a good system of regulation and proportioned directly to its environment, it has come to be the most usual form for large powers in all our great stations, although European constructors seem to continue to employ the older type of horizontal engine for such work, even up to the largest powers. At the Paris Exposition of 1900, for example, the foreign builders exhibited a large proportion of engines of the older types in all the sections devoted to light and power distribution, while practically all the later contracts in the United States for large stations include contracts for the vertical engine in units of several thousand horse-power each. Regulation is effected by the shaft governor wherever the speed of revolution permits and usually by the loaded governor of the Porter type and Corliss gear in other cases. No marked change is observable in this direction since the earlier date when the subject was discussed in the columns of the pioneer journal. The changes brought about in the interval have been mainly at the engine in the adaptation of the machine to the delivery of larger quantities of work from the single unit at minimum cost and with uniformity of current and tension at the dynamo.

In illustration of this later practice it is well to compare the condition of the steam engine industry at the beginning of the era of transmission of light and power electric currents with the industry of to-day, the changes of a quarter of a century or less. Then the stationary engine was usually a Corliss, a Greene or some equivalent form, operating under 60 to 75 lbs. of steam, a horizontal engine, with a maximum speed of about 60 revolutions and a speed of piston of about 450 ft. a minute, regulated by a fly-ball governor and consuming about 2½ or 3 lbs. of good fuel, 20 to 25 lbs. of steam, when condensing, per horse-power-hour. The boiler was a plain low-pressure fire-tube construction, but it was as economical a steam producer as the boiler of to-day. The dynamo was usually of the two-pole type, delivering a continuous current at low voltage and with some uncertainty as to steadiness of operation, and was belted to the engine. The "plant" occupied large floor area, extensive bunker capacity was required, and costs of current were what would be to-day thought very large in the then largest stations, and most extravagant in smaller plants. The tendency to force economy in all departments coming of the competition which always marks the introduction of new and important advances in the industries, especially in this country, calling for higher steam pressures, safer boilers, more economical engines, generators for high tension, and especially the high pressure practice coming in with the alternating current, have forced a revolution in engine construction and operation, as in every other department of the business. Steam pressure, for a long time held by the builder of boilers and by the conservatism of users at about 125 lbs. as a maximum, suddenly broke over its earlier bounds, and 150, 175, and, of late, 180 and 200 lbs. pressure have come to be accepted as good practice, while engine speeds have increased and speeds of piston have risen to 600 and 750 ft. per minute; economy has been gained until 15 lbs. of steam per ihp per hour, and 1½ to 2 lbs. of fuel are as usual as were twice those figures 25 years ago. A total cost of as little as $10 to $12 per horse-power per annum is now sometimes reported from the modern engine room. Regulation, formerly thought good when variations from the mean did not exceed 2 or 3 per cent, was brought, by improved governors and adjustments, especially with the "shaft governor" and inertia effects, to 1 per cent variation; high speeds of rotation permitted the variation within the revolution to be made imperceptible with moderate weights of fly-wheel, an essential in alternating current work.

The law of this progress and the record of its achievements cannot be given in detail in a short study like this, but, fortunately, graphical methods of exhibition of these changes may be made to tell, in a single line, often, more than pages of description and historical disquisition. It is known that the gain by increasing pressures, *properly utilized*, should be proportional nearly to the logarithms of the pressures employed. Thus, the consumption of steam and fuel should be measured by some such function as $W = a / log\ p$;

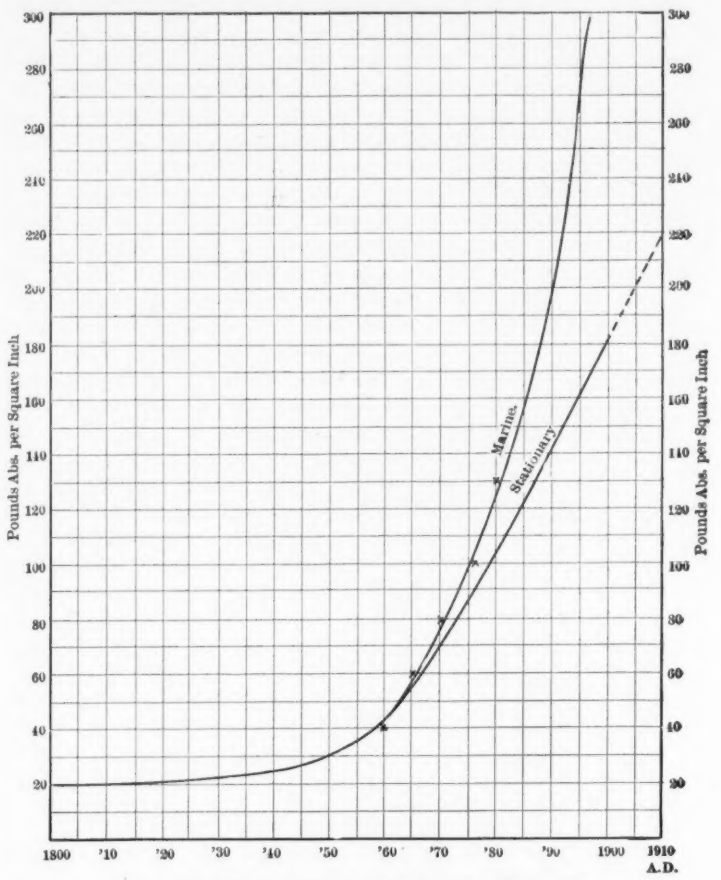


FIG. I.—RISE IN STEAM PRESSURES, 1800-1900.

where a is a constant derived from study of current practice and is equal to about 30 lbs. for good work in engines adapted to the pressure.

The accompanying diagram shows the progress in rising pressures, through the century, for marine and for stationary work by recognized leaders in the business of engine construction, and it is seen that the progress of the past two decades, the period with which we are especially interested at the moment, is about, as shown on the chart, from 90 to 180 lbs., just doubling, and with promise of rising to 220 in the next few years, although probably no one would be surprised, now that boilers may be had for practically any pressure likely to be desired, to see a more rapid rise to the height and growth observed in marine practice of the most radical sort as exhibited in the companion curve. The rise in economy, as measured above by weights of steam, or thousands of B. T. U. per ihp per hour, would thus be as follows:

RISE IN ECONOMY.

Pressures	100	200	300	500	1000
Expansions	15	30	45	75	150
Steam or B. T. U. per ihp....	13-15	11-13	10-11	9-10	8-9

In the rise from 90 to 180, or from say 100 to 200 lbs., absolute, the gain should be expected to be about 15 per cent from this cause alone. Accessions of efficiency due other improvements, as the more

general and intelligent use of the multiple-cylinder engine, the employment of superheating, reheating, condensation and the principles of finance have conspired to effect gains which cannot be so well illustrated as the above.

The next diagram, however, in which gains are exhibited as measured by the "duty" attained—work per 100 lbs. of fuel—and by B. T. U. per horse-power-hour, may aid the mind in the endeavor to perceive what has been accomplished. The last decades have raised the duty from about 120,000,000 to 160,000,000 foot-pounds per 100 lbs. fuel of best grade and with best engines under most favorable conditions, while the heat consumption has correspondingly dropped from 15,000 to 11,000 B. T. U., or from about 15 to about 11 lbs. of dry steam per ihp per hour. The thermal wastes have, meantime and

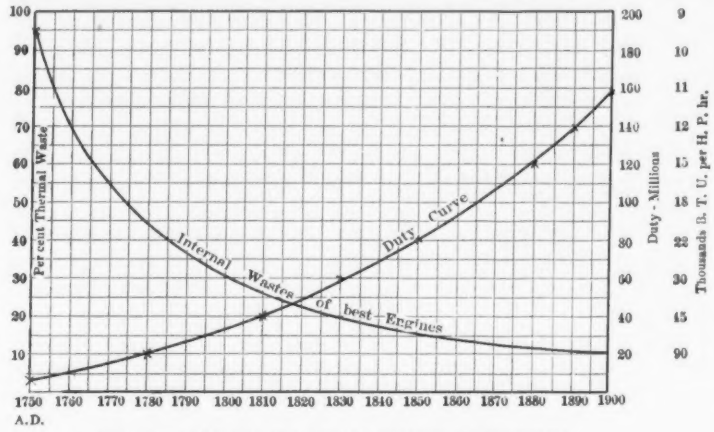

Per cent Thermal Waste
Internal Wastes of best Engines
Duty Curve
Duty - Millions
Thousands B. T. U. per H. P. hr.
1750 1760 1770 1780 1790 1800 1810 1820 1830 1840 1850 1860 1870 1880 1890 1900
A.D.

FIG. 2.—PROGRESS IN STEAM ENGINE EFFICIENCY.

complementarily, fallen off from their amounts two decades ago in full proportion.* The two sets of figures also exhibit the difference between good and the best work.

The twentieth century comes in with threatenings of a possible new catastrophic break in the line of progress. The steam turbine, the steam engine of "maximum simplicity and of highest thermal efficiency,"† in its ideal, at least, is now rapidly coming into sight, and its principles of design and construction are as rapidly becoming recognized. Its promoters are confident that it is to find some extensive and important place, displacing the reciprocating engine, and its first and most successful market has been found in the field of electrical engineering.

Still another possible break in the smooth curves of progress of the century, to date, is seen as a coming event by some authorities: the replacement of the steam engine by the gas engine, already successful in many fields and on a small scale, now beginning to perform larger tasks, to deliver hundreds of horse-power and to meet every requirement of the engineer, scientific and practical, successfully, including that of finance.

As illustrating the best work of the century and its progress through a hundred years of invention and of evolution of its scientific foundations, the following table may be studied in comparison with the diagrams of duty and efficiency already given and the figures earlier supplied. They may be taken as exhibiting the best work of the nineteenth century and the figures with which we enter upon the twentieth. They are largely pumping-engine records, as in that field the load is practically always constant and conditions are steadily those which permit best work, but the stationary engine for factory and power plant and electric lighting work, if not attaining these figures in regular and usual operation, may at least be made to approach them under the most favorable conditions of mean load.‡

The world's records are better shown diagrammatically, in illustration of their real value, actual and comparative, by entering them as data upon a diagram exhibiting the method of variation of efficiency with increase of steam pressure as in the next figure. Here the co-ordinates are steam pressures and heat consumption and the curves are logarithmic, exhibiting the graphic reproductions of the logarithmic equation of efficiency, as already written, with differing constants. The curve corresponding to minimum values of the constant and of the abscissas is the curve of efficiency of the ideal, purely thermodynamic machine, with rising pressures as measured by heat consumption. That at the extreme right is the curve corresponding fairly well to the actual reported performance of the average simple engine of moderate size and good construction, while the intermediate curves correspond to cases illustrated by multiple cylinder engines, with varying steam pressures under favorable conditions otherwise. The data entered on the diagram in form of crosses distributed over half the full area of the plate are the records of the world's "record breakers" of the last decade.*

MINIMUM STEAM CONSUMPTION, 1900.

End of the XIXth Century. Best Records.

	I.H.P.	Steam Pressure	Speed of Piston. Feet per Minute.	Per I.H.P. per Hour. Pounds Limited.	B.T.U.	Foot-Pounds Duty per 1,000,000 B.T.U.
Simple Engine.						
Sulzer	284	87	372	18.4	20,250	88,000,000
Corliss	137	62	...	17.5	19,250	92,630,000
Compound.						
Dujardin	548	90	570	13.46	14,800	120,400,000
Sulzer	247	85	493	13.35	14,700	121,100,000
Wheelock	590	160	612	12.84	14,100	126,400,000
McIntosh & Seymour	1,076	125	800	12.76	13,000	137,000,000
Leavitt	643	135	371	12.16	13,400	133,000,000
Triple Expansion.						
Sulzer	615	141	516	11.85	13,000	137,000,000
Reynolds	574	120	203	11.68	13,056	140,817,000
Leavitt	576	185	240	11.22	12,242	141,855,000
Snow	773	156	215	11.26	.....	150,100,000
Quadruple.						
Hall & Treat	16	300 400 500	220	10.80 9.65 9.75	13,500	132,000,000
Nordberg	712	200	250	12.26	11,158	162,948,824

It is seen at a glance that the simple engine has been made to give a better performance than that indicated by the curve set as its criterion, while the compound engine does relatively better, thus tested, than the triple. The quadruple has not yet reached its standard line. The compound engine, in other words, is the most perfected of all the types, and in one case at least ranges in actual value directly beside the best quadruple, allowance being made, as here, for difference due variation of steam pressure.

Financial rather than thermodynamic considerations, however, control, and properly, the design of every steam engine as of every other construction in the whole realm of the industries and of industrial engineering, and it is by no means the fact that the best engine, from the thermodynamic point of view, is the best engine from the standpoint of either the engineer or his client. The latter is compelled to measure efficiency by the amount of power delivered for his special purposes and usefully applied per unit of total operating costs, including all interest accounts. This fact makes it often advisable to design, to construct and to use an engine of very different proportions from that which would be employed where, as is so usual for pumping engine construction for public works, specifications are written from the point of view of the coal pile alone. This fact is well exhibited in the accompanying diagram which the writer devised and has been accustomed to use in illustration and enforcement of this principle.

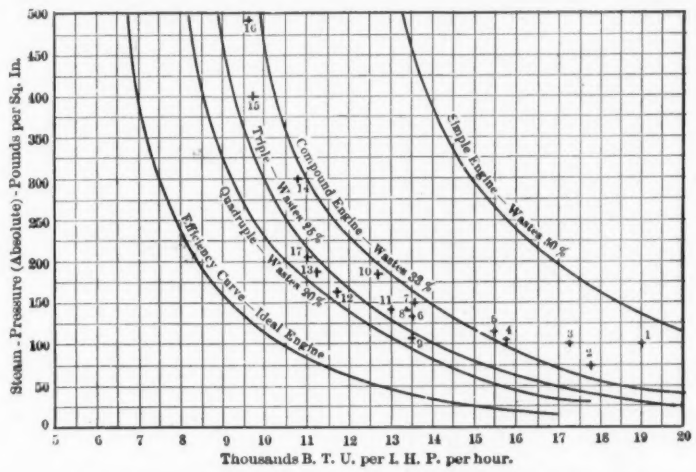

Steam - Pressure (Absolute) - Pounds per Sq. In.
Simple Engine — Wastes 80%
Compound Engine — Wastes 88%
Triple — Wastes 85%
Quadruple — Wastes 80%
Efficiency Curve — Ideal Engine
Thousands B. T. U. per I. H. P. per hour.

FIG. 3.—PERFORMANCE OF BEST TYPES OF ENGINE.—1900.

1, Simple. 2, Simple. 3, Compound, 3 to 1. 4, Compound, 3 to 1. 5, Compound, 7 to 1. 6, Compound, 7 to 1. 7, Triple. 8, Triple. 9, Compound. 10, Compound, 7 to 1. 11, Triple. 12, Triple. 13, Compound. 14, 15, 16, Quadruple. 17, Quadruple.

* Promise and Potency of High Pressure Steam; R.H.T.-Trans. A.S.M.E.; No. DCCXVIII., Dec., 1896; Vol. XVIII., 1896. Pages 160-218. Also, Thurston's Manual of the Steam Engine, Vol. I., 1900.

† The Steam Turbine. R.H.T.-Trans. A.S.M.E., Dec., 1900.

‡ The Steam-Engine at the Close of the XIXth Century, R. H. T.; Trans. A. S. M. E., No. 832; Dec. 1899; Vol. XXI., pp. 181-241. Also: Thurston's Manual of the Steam-Engine, Volume I., Chap. IX., 1900.

* The Steam Engine at the End of the Nineteenth Century; R.H.T.-Trans. A.S.M.E., No. 832, Dec., 1899; Vol. XXI., pp. 181-241. Manual of the Steam Engine, Vol. I., Chap. IX., 1900.

Here the coördinates are heat, consumptions per unit of power and of time as ordinates, and the ratios of expansion at which such economies are measured as abscissas, the latter thus constituting the measure employed as a criterion for this case. The lowest line is the ideal curve of variation of efficiency with varying ratio of expansion for an assumed case taken as typical, as, for example, at 100 lbs. initial gauge pressure. The gain in economy is progressive and

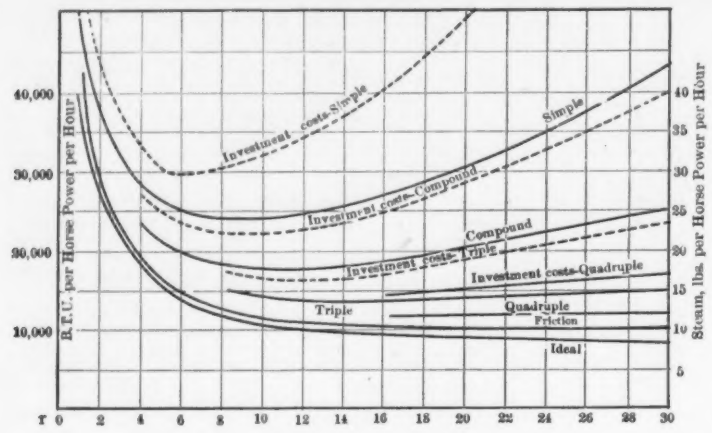


FIG. 4.—COMPARATIVE EFFICIENCY OF ENGINES.

without limit until, outside the figure, the expansion line intersects the back pressure line. The second curve, directly above, marked friction, shows the modification of efficiency due the increasing proportion of waste by friction, which efficiency has a limit at the point, also outside the diagram, at which the expansion line intersects the line of which the ordinate is the sum of back pressure and the friction resistance, both measured in pounds per square inch of piston area.

The curve marked simple is that of the varying efficiency of the single-cylinder engine in the actual case, in which the wastes due internal cylinder condensation are added to the friction loss and the ordinates are thus measured of the cost in heat and steam per horsepower per hour for the case taken, which costs find a limit with progressing expansion, at the point at which further expansion would increase wastes by friction and condensation faster than gains by further expansion of the steam behind the piston. In this case this point was found at about eight expansions. On the curve for the compound engine, in which the internal wastes are assumed to be reduced to one-half those of the simple engine, a similar limit is discovered at between 10 and 12, while a limit for the triple-expansion engine appears at a ratio of expansion not far from 16 or 18, and for the quadruple at about 20.

When we add the investment costs and various incidental expenses, reduced to equivalent measures of heat and steam, the above ratios of expansion become restricted, as seen, in this instance, to 5 or 6 for the simple, to 8 to 10 for the compound, to about 12 for the triple and to about 16 for the quadruple machine. Every engine thus has one best ratio of expansion and corresponding suitable "rated power,"which figures must be identified for that engine under the particular financial conditions of its proposed use if the engineer is to make his task a properly fruitful one, and if his client is to profit in maximum degree by his work and by his investment in a power plant. It should be further noted that this problem involves an earlier and equally essential investigation to determine the best proportions of the boiler which supplies the steam.*

Summarizing what has been here collated regarding the progress of the last decades of the nineteenth century and the position of the great motor at the commencement of the twentieth century, it is seen:

1. That steam pressures have risen until double those usual two decades ago, and meautime the water-tube boilers, of which the writer said a generation ago:† "Their use will become general to the exclusion of the older and more dangerous forms of boiler," have come in to meet the demand for safe, compact and economical steam supply in large quantity and under peculiar conditions. About 180 lbs. is now standard, 200 in sight. The limitation at the boiler is disappearing.

2. The ratio of expansion adopted in the engine has risen in magnitude with increasing pressures and has now come to be intelligently limited at that value at which variation either way would reduce dividends on the capital employed in conjunction with the steam plant, averaging a figure giving a terminal pressure of 10 or 20, with or without condensation.

3. The speeds of piston and of rotation have been slowly increasing in compliance with the demands for greater efficiency, thermal and mechanical, and for reduced volume, weight and cost, which elements of design were first completely defined by Charles T. Porter forty years ago. Standard speeds rise to nearly 1000 ft. and to 125 revolutions and upward in large powers.

4. The demand for steam power in electric light and power plants has led to the permanent and general employment in small sizes of the engine advocated by Porter, as a class, with, however, a shaft, governor controlling its positive-motion valve-gear, a compact and strong construction with high speed of piston and of rotation and exceedingly fine regulation. For large powers the engine has come to be very generally a vertical direct connected machine, with Corliss or Greene or equivalent steam distribution and regulated by a loaded governor and operated at a speed of piston exceeding 600 feet a minute and at somewhere about 100 revolutions a minute. The stroke is usually shorter in proportion to diameter of cylinder than formerly.

Finally: The steam turbine seems to have passed its experimental stage and to have found permanent place in the work of power production. The gas engine is coming forward as a rival of the steam engine.

5. The scientific principles of the thermal, dynamic and thermodynamic action of the engine, which control its energy transmission and transformation, have come to be well understood, not only by the man of science but also by the designing engineer, and science and art, theory and practice now unite intelligently to produce the modern power plant, developing any stated amount of power at the boiler and at the engine with maximum total efficiency. These principles are now taught in every technical school of any pretensions to high standing and are thus learned by the new generation of practitioners in engineering at the very threshold of their offices. Professional education and training now underlie all engineering.

6. The limitations of the pure theory by the actual conditions controlling in practice are now recognized, and for the first time the designing engineers of the country are adapting the engine to the requirement that it shall illustrate a maximum *total* efficiency.

7. The requirements of a sound financial basis of construction have come to be seen clearly, and by some designers definitely incorporated into their constructions. The one obstacle in this direction of improvement is the inclination of designer, constructor and user alike to adopt specifications calling for a maximum "duty" in fuel consumption rather than in consumption of capital and its earnings.

8. All the details and accessories of the steam engine have come to be similarly perfected by the conjoint application of the principles of science, thermal and dynamic as well as thermodynamic, and of finance and practical business, in the endeavor to secure a complete design that shall at once illustrate exact methods of design and proportion, good construction and well-chosen materials and the precise adaptation of the whole and of its every element to the fundamental purpose—the production of a stated amount of power with regularity and certainty and exact adaptation to load and in such manner as will in largest degree promote the production of dividends.

The outlook is exceedingly promising and the twentieth century opens full of interest and full of hope for the world of engineering as well as for all good citizens. While we have made little progress as yet, so far as can be seen, toward that ideal of all engineers familiar with energy transformations and uses, the direct transformation of the potential energy in our coal beds into mechanical power, or toward the storage and utilization of the radiated energy of the sun's rays—both essential to the prolongation of the life of the race in the temperate regions and on the earth—we have certainly reached a point far in advance of the best of a century ago, or even a generation ago. But we have apparently perfected the standard forms of steam engine so far that we cannot expect much or rapid progress later; we have reached a point at which the gas engine is threatening to rival the product of the genius of Newcomen, Watt and Corliss; we have come to a perfection of regulation of the contemporary machine which even permits alternating machinery to be operated in parallel when the specifications demand, as is now the fact, that the variation between the pairs shall not exceed 1-60th the angle be-

* Manual of the Steam Engine; Vol. I., Chap. IX.

† Report of American Institute Boiler Trials, 1871; Trans. Am. Inst., 1872; Jour. Frank. Inst., 1872.

tween two successive poles and the variation in speed in successive revolutions, invisible to the eye, is less than one revolution per minute; we have brought the steam turbine, apparently ideal in this last respect, to nearly the efficiency of the best of the alternating engines;* we have brought the gas engine to a consumption of fuel approximately a pound, sometimes even less, of good fuel per horse-power-hour; we have, in summary, reached a point at which the engineer has opportunity to once more use his inventive powers in the production of new types of heat engine and in their perfection in the devising of new methods of energy transformation, in the substitution of new heat engines for old and in the supplanting of *all* thermodynamic engines by other forms capable of an ideal efficiency of unity, as in electro dynamic transformations.

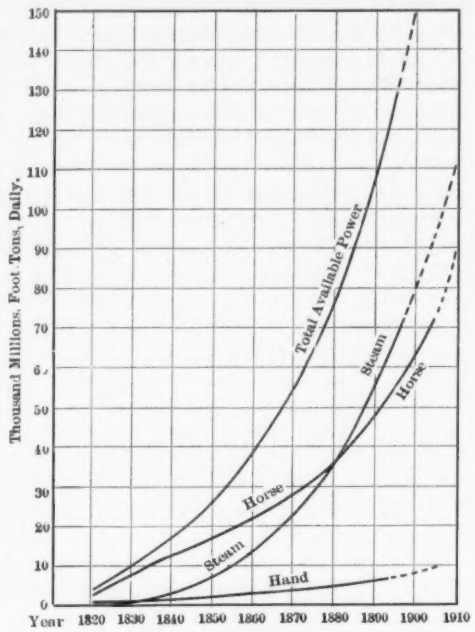


FIG. 5.—AVAILABLE POWER IN THE UNITED STATES.

There was never a time in the history of the world when civilized man had better cause for confidence. Assuming that the craze for extension of territory among nations and the tendency toward demagoguery in self-governing countries shall soon have died out, and that all nations then will be permitted to give their entire energies to their own internal development and improvement, as have our own people during the recent period to which we have given especial attention, the "Trend of Progress"† (Fig. 5) undoubtedly is toward rapid evolution of all desirable advances in the arts, in the condition of the world and in the character and virtues of our people. And in no material department of the world's progress is there a larger opportunity for the live man, with suitable preparation for a professional career, whether in invention, design or construction and exchange, than in the field of electrical engineering practice and in the further perfection of the steam engine and its rivals, of the mechanisms for transformation of energies in the supply of the motive power of the industrial world.

Centennial Reflections.

The general public have but a limited understanding of the great growth already attained by the industries devoted to the practical application of electricity and the enormous development of which they are capable.—HENRY VILLARD.

All the elements whose aid man calls in will some time become his masters, especially those of most subtle force. Shall he, then, renounce steam, fire and electricity, or shall he learn to deal with them?—EMERSON.

If the army of would-be inventors could enter the field with a full knowledge of what science has already done, the conquest of new territory would be still more rapidly accomplished, and not a few of those whose names would be remembered would be found to have come up from the utilitarian ranks.—PROF. W. A. ANTHONY.

The mechanic well knows that absolute truth is unattainable, but he nevertheless values highly the approximation to truth which allows him approximately to ascertain the result of given simple material combinations.—FLEEMING JENKIN.

The great names in connection with our progress in knowledge as to the real nature of electricity, irrespective of a mere study and extension of its known facts, are Franklin, Cavendish, Faraday and Maxwell.—OLIVER J. LODGE.

Electricity is subject to laws as definite and invariable as those which govern the mechanical motions of the planetary system.—JOSEPH HENRY.

* The Steam Turbine.—R. H. T., Trans. A. S. M. E., 1900.
† The Trend of National Progress.—R. H. T., N. A. Rev., 1895.

Electrical Power Transmission.

BY DR. LOUIS BELL.

THE art of electrical power transmission is so recent in its origin that howsoever one looks at it one sees only a fragment of the past and a substantial present, without one certain glimpse of the future. It is as if one were set down in a street of a strange city with a few dingy blocks visible behind him, solid and even beautiful structures around him, and a turn in the street just ahead. What is beyond it can only be told when the corner is rounded—whether stately piles of steadily increasing grandeur or the grim abutments of the city wall. The stream of hurrying citizens moving onward suggests the former—if we only knew how far they were going.

It is less than a decade since electrical power transmission could fairly be called an art by itself, even though the first attempts date back a little further and some of the pioneering work had already been done, and well done. It was really the Frankfort-Lauffen demonstration that more than any other one thing gave the impulse that has carried the work along. It was a daring conception, cleverly and successfully carried out. Two years passed before the first commercial polyphase distribution plant was put into operation in this country, although some isolated plants were started within a shorter period, but, once initiated, the work went on with a rapidity which has been unexampled even in the swiftly written history of electrical progress. The distances covered have grown from a few miles to more than eighty, and the voltages have jumped from a few thousand to the tremendous figure of forty thousand volts. In this connection must not be forgotten the wholesome influence of the early lighting plant at Pomona, which, small though it was, and devoid of any permanent influence in its constructional features, yet rendered important service to the art in that the fearless use of 10,000 volts stiffened the backs of American engineers for the more serious work that was soon to come. Once the fear of high voltage was allayed, the work of development was rendered vastly easier than before, and it became practicable to attempt distances great enough to increase enormously the number of available sources of power. The outcome has been a complete and radical change in the methods and aims of hydraulic development. Up to this period factories had to come to the power; now the power comes to them, so that the conditions of general growth are not cramped by the necessity of utilizing locations undesirable save as regards power supply. It is hard to estimate the economic value of this change, but it is assuredly very great.

At the present time, to speak by the card, it can be considered with entire propriety that with favorable conditions as regards market, power can be electrically transmitted as a commercial proposition for distances of a hundred miles and upwards. In general, such a transmission over 20 or 30 miles can be made to pay in most sections of the country if cheap water power can be secured as the primary source of energy. There is some danger that the possibility of easy power transmission may serve to put a fictitious value on undeveloped powers that may lead to checking temporarily their utilization. Methods of transmission have settled for the most part into a few well-defined channels, and the engineering features of the work are little to be feared.

The generators, always polyphase, may be of any of the species of that genus, but the line is practically always three-phase. For moderate distances of transmission high voltage generators have come into very extensive use for sound reasons of economy, but whenever it is desirable to use 15,000 volts or more upon the line, recourse is usually taken to raising transformers. The frequency, after much violent and acrimonious debate, has usually settled down to 60 ~ for ordinary transmission work, with a tendency to lower alternations for very long distances and for special motor work. The line voltage is busily chasing a limiting value, with some good chances for catching it, although the hunt is by no means over. Line insulation, once feared, has not proved a serious matter, in view of the constant improvements in material; and the dubious question of climatic conditions as bearing upon the maintenance of line insulation has found a favorable answer. Line pressures of 10,000 to 15,000 volts are carried in the severest climates to be found in the United States with such complete freedom from any difficulties chargeable to weather that it is safe to say that these voltages

will be much exceeded in the future. Inductance and capacity effects, once dreaded, have been shown to be more controllable and far less generally serious than had been supposed. So much for a brief outline of the present condition of things without going in detail into methods or the characteristics of existing commercial plants.

Perhaps the most striking thing about it all is the remarkable fact that the whole development has been by swift and steady progress without failures or retrogression. It rarely happens that such rapid advance is not accompanied by serious and costly blunders, but throughout the growth of modern power transmission there has been wonderful exemption from such evil chances.

And now for the future—what may it reasonably be expected to bring forth, and in what wonder-working may it have a part? At present, power transmission is showing a tendency to settle into well-defined lines of engineering. The apparatus is every year bigger and better, and the voltage of transmission is steadily rising toward the limit at which the dialectric strength of air seems to fail. What is there beyond? Are we to grow along these lines, or are new methods to be disclosed? For one, I see no reason to expect any very radical changes for some time to come. The oft-repeated prophecy that the power transmission line of the future will be underground, rendered perfect by some strange and occult method of insulation, I see no reason whatever for regarding as anything but a dream. There is not one thing in the present state of the art to hint at it, and on general principles it is a thing to be dreaded. It is a sufficient task to keep fifty or a hundred miles of line in order even when every inch of it is in easy view, and a tithe of the expense of putting it under ground would clear it of most of the dangers which now beset it. It increases the difficulty of repairs a hundredfold to have the conductors out of sight. The whole matter stands in a position entirely different from that of the distributing circuits, where the wiring may have to be somewhat complicated and is likely to be greatly interfered with in many ways. In some places it may be necessary or desirable to put a transmission line under ground, but until there is a complete revolution in our methods of insulation and a complete upheaval in the cost of material, underground work at modern high voltages should be shunned like a pestilence. Transmission of energy without wires in any considerable quantities seems equally to belong in the category of the commercially improbable. As a mere engineering feat one might accomplish something along this line, but any scheme that utilizes earth or air as part of its transmitting system is certain to involve not only enormous and probably insurmountable difficulties in the way of directive action, but commercial and legal difficulties that are practically even more formidable. Even so simple and feasible an operation as working a simple alternating circuit at 100,000 volts or so over one wire and the earth would start a current of litigation truly wonderful to contemplate.

On the other hand, there are likely to be enormous advances in power transmission over paths which are already laid down on the map. It seems quite possible that the present limit of voltage may be greatly exceeded by the very simple process of separating the wires, even if they have to be put on separate pole lines. It is safe to say that without any revolution in general methods the cost of the conductor can be so far decreased that it will have little importance as a limiting factor in commercial work. It must be remembered that most transmission is from natural sources of energy and that these are so distributed that it does not take any great increase in the radii of action already established to bring such sources into competition with each other instead of into competition with fuel. Competition in electrically transmitted power is not unknown even now, and until the general demand for power is far greater than now such competition will have to be reckoned with. The effect of improvements will be to utilize the water powers of the country to the fullest extent of the demand for power, and this can be done without any immense influx of new methods in the art. It is my judgment, too, that there will be very great advances made in the direction of power transmitted directly from coal mines. At present the sole example of such practice on a considerable scale is that for the mines of the Witswaterrand. But that is only the begnning. One can, without a great stretch of the imagination, picture a mine of low grade coal as the coal bunker of a future power house, with the fuel taken direct from the breakers to the furnaces by mechanical stokers, with 10,000 or 20,000-hp steam turbines directly coupled to the generators, delivering power at a cost so low as to compete on favorable terms with all but the cheapest water powers.

If one traces the cost of a ton of coal back to the mine, it is astonishing to see how little of the current price is chargeable to the fuel itself and how much is taken up by transportation and by the profits of combinations and middlemen of various degrees who exist only by the strange, long-suffering sluggishness of the public that is their prey. Some day the worm will turn and there will be an era of startling developments. At present the price of fuel is moving steadily upward, and while the world's stock is yet far from being depleted, it is certain that the tendency is such as to make methods of conservation of vast industrial importance. And we must not forget that our water powers also are threatened. If the policy, reckless and destructive, of the past half century is carried on much longer, the availability of our water powers will be greatly lessened. All this points to the growth of power transmission from coal mines as a most important matter, tending to lessen the depletion of the coal supply and to supplement the failing water powers.

It is safe to say that such transmission will greatly modify existing conditions in cities. There is even now no logical reason why a pound of coal should ever be burned in a city unless for heating purposes. So far as power is concerned, transmission on a large scale from water power or coal mines can solve the whole problem of industrial power, and gas for heating can be piped to do the rest. One huge coking plant providing fuel gas and utilizing the coke *in situ* for the development of electric power would work a transformation in New York, Philadelphia or Chicago that the mind can hardly grasp as yet. Production of all the material for heating, power and light on such a colossal scale would greatly economize the consumption of fuel for the required work. And all this is no dream, calling out of the unknown strange new forces and occult methods that are without the scope of the imagination, but it is a realizable commercial condition, demanding only such daring skill and sound judgment as have already brought our country to industrial primacy.

There are many things for which one might wish in the development of electrical power transmission—electricity direct from coal, a storage battery cheap enough and durable enough to allow its use in a very extended field, an insulating substance with the mechanical properties of a metal, but whether we get these or not, there is work enough to be done. The demand for power upon a huge scale depends on the civic and industrial conditions that may exist in the future, and what these may be no one can tell. It is conceivable that before the dawning century shall end the world's aims and work may be materially changed, or even that the march of modern discovery and invention may be temporarily stayed. Of this much, however, we are certain, that the present generation has before it work enough to last for several decades without calling upon any strange genii. Our children and our children's children will perhaps look back upon our achievements with good-natured amusement, but the last quarter of a century has wrought well the foundations on which they may build beyond our dreams.

Chemistry and Electricity.

The most remarkable advances which have been made lately are due to cheap electric current, says Prof. W. Ramsay, of argon and helium fame, in the New York *Sun*. The electrolysis of alumina, dissolved in fused cryolite to obtain aluminum, an operation carried out at Schaffhausen on the Rhine and at the Falls of Foyers in Scotland, the electro deposition of pure copper for electric wires and cables, electro silvering, gilding and nickeling, all these are instances where decomposition of a compound by the electric current has led to important industrial results. At present soda and chlorine are being manufactured by the electrolysis of salt solution contained in rocking trays, one of the electrodes being mercury, by the Castner-Kellner process. This manufacture is being carried on at Niagara, as well as in England. But electricity as a heating agent finds ever-extending application. Henri Moissan (professor at Paris) led the way by utilizing the enormous heat of the arc in his electric furnace, thereby, among other interesting reactions, manufacturing diamonds, small, it is true, though none the less real. The use of electricity as a heating agent has received new applications. Phosphorus is now made by distilling a mixture of phosphates of lime and alumina with coke; a new polishing agent has been found in "carborundum," a compound of carbon and silicon produced by heating in an electrical furnace a mixture of sand and coke, and cyanide of potassium, almost indispensable for the extraction of gold from ores poor in gold, is now manufactured by heating a mixture of carbon and carbonate of barium in an electric furnace in a current of carbon monoxide. These

Telephony.

BY KEMPSTER B. MILLER.

FROM what was considered an interesting toy at the Centennial in 1876, the telephone has grown to be one of the most indispensable factors of our modern civilization. The development was slow at first, the great invention being for the most part unappreciated by the public. Once started, however, it surpassed, year by year, the hopes of those most interested in its welfare. Exchanges equipped for an ultimate capacity of hundreds quickly reached that limit and were built and rebuilt for as many thousands. It was frequently impossible for the manufacturers to complete an equipment and ship it before something so much better had been designed as to render it out of date.

The carbon microphone transmitter, the flexible cord switchboard, the multiple switchboard, the adoption of metallic circuits, the central battery system and lamp line signals, in the order mentioned, form perhaps the most prominent landmarks in the history of the development.

The transformation of the toy into the instrument of universal utility has been achieved through the work of such men as Hughes, Edison, Kellogg, Scribner, Lockwood, Carty, Dunbar, Dean, Hayes, Stone, Sabin, Hibbard, White, and McBerty—all Americans.

At the present time more energy is being spent in improving the facilities for adequately handling the inter-connection of the ever-increasing number of subscribers than in improving the actual efficiency of transmission, although the latter problem is not being neglected.

The present tendency is toward the use of larger exchanges and the placing of jacks on closer centres than has heretofore been thought desirable. The old idea of 6000 lines being the maximum number desirable or practicable in a multiple switchboard is being rapidly wiped out, and several boards have already been constructed very much larger than this.

That central battery systems have come to stay no well-informed person can doubt. Their inherent advantages, such as automatic signaling, the simplification of subscribers' apparatus and the ease and cheapness of maintenance have caused them to work a perfect revolution in commercial telephony within the last few years.

The incandescent lamp for both line and supervisory signals seems to be gradually gaining ground over all forms of mechanical signals, the reason being that the lamp is at once effective, essentially self-restoring, cheap, and in itself the heir to but one form of trouble—burn-outs. To be sure, the use of a lamp carries with it the necessity, or at least the strong desirability for a relay, but a relay is a more reliable piece of apparatus than a drop, is more readily accessible on account of not being placed on the front of the switchboard, and the combination of lamp and relay is hardly more expensive than a properly constructed self-restoring drop. The two-lamp system of supervisory signals is now the most modern practice in exchange working, as it keeps the operator constantly informed of the condition of two connected lines, and therefore does away almost entirely with the necessity of her listening in. This system alone has effected a possible increase of about one-third of the number of subscribers handled by any one operator, with a corresponding reduction of operating expenses.

There is a growing tendency toward more substantial equipment and construction, toward the employment of a higher grade of men in both the technical and business departments, and what is of even more importance, toward giving the public the service and the treatment that it demands and should have.

The greatest factor to-day in the general betterment of telephone service and its more universal extension, is the independent movement, which by its fierce and growing competition has forced its rival to more progressive methods and has developed new methods of its own.

It is difficult to see very far into the new century, but we can form some ideas from present tendencies, and, not having lost faith in the progressiveness of our age, predict events which by their desirability now seem sure of accomplishment in the future.

The present rapid increase of the population of the business centres, the rapidly increasing popularity of telephone service, and the reduction in rates for service, will render the building of exchanges very much larger than any in existence at present. A single exchange having 100,000 lines will be built as soon as there is an actual demand for it. This figure perhaps sounds preposterous to many who are acquainted with the difficulties that have been encountered in building switchboards of scarcely more than one-twentieth this capacity, but the idea is perfectly practicable and a switchboard for such an exchange could be built to-day were there a necessity for it. That the demand for such an exchange will exist cannot be doubted. The telephone will be considered more and more in the light of a necessity rather than a luxury in the home as well as in the business offices. Why should not telephone service become as common as the use of gas, electric light and water?

In systems which, on account of the geographical distribution of the subscribers, require several different central offices with a large percentage of trunked connections, I think the tendency will be to do away entirely with the multiple jacks in front of the answering or "A" operators and to extend the multiple jacks only on the sections used for incoming trunking. Such a course will probably prove economical where the conditions are such that as great a number as 75 per cent of all calls need to be trunked. The adoption of such a course would mean that all calls would have to be trunked instead of 75 per cent of them or over, but the uniformity of service, the great saving in multiple jacks and cables and therefore of initial cost and expense of maintenance, would probably outweigh the advantages arising from the ability to make 25 per cent or fewer of the calls without trunking.

With the increasing size of exchanges and the ever-increasing demand for the subway space made by all branches of municipal service, there will be a need for cables of larger conductor capacity for a given size. There is already a tendency toward the reduction of the size of the wires in underground and aerial cables. Instead of conductors corresponding in size to No. 19 or No. 20 B. & S. gauge, as now almost universally adopted, I think the future standard for crowded districts will be nearer to No. 24 B. & S. gauge, with a steel strand running through the centre of the cable, if necessary for strength. To partially make up for the smaller size and greater resistance of the wires in the cables, an increase of the voltage used in the common battery systems will probably take place, and instead of the present standard, which is from 20 to 24 volts (10 storage cells), it will probably be double this or more. This change would perhaps mean the necessity of better insulation and better methods of protecting apparatus than those now in vogue.

The use of automatic coin-collecting pay stations will probably greatly increase in the near future, and those devices in which the coin is necessarily deposited before a call can be registered at the central office, but which allow the return of the coin to the user in the case of an uncompleted connection, will supersede those in which the coin is not deposited until the connection is completed. One reason for this is the delay frequently caused by the user in finding a coin of the proper denomination after the operator has made the connection. The charge for such connections will be 5 cents or lower, and will probably keep pace with street car fare.

The automatic switchboard, that is, the switchboard in which no operators are required, will probably have some field of usefulness (which it has not, up to the present date,) but only for very small private exchanges. If there were any necessity or real desirability for the automatic in large exchanges, the probabilities are that mechanical genius would eventually triumph over their at present seemingly unsurmountable practical obstacles. The present consensus of opinion seems to be that the automatic exchange is impracticable, and even if practicable would not be desirable. For this reason, if for no other, its future does not present a promising aspect.

No practical results have recently been recorded arising from any of the various schemes for radically increasing the transmission efficiency over very long distances. The telephone repeater seems to have met with no practical success, and the various proposed systems of associating impedance coils with the line circuit for improvement in the talking circuit itself are yet, so far as the public is aware, in an experimental stage. Notwithstanding this, and not pretending to know how, I believe that long before the new century is ended it will be possible to talk from San Francisco to London, or, in fact, to almost any other portion of the globe. To believe otherwise is to acknowledge defeat at the very outset and to lose faith in the progress of science and invention.

Electric Lighting.

BY PROF. DUGALD C. JACKSON.

OUR grandfathers retired by the light of a tallow dip; our fathers, in their youth, were taught the beauties of lard oil as an illuminant; but the advantages of refined petroleum and illuminating gas drove from the field the older means of illumination. These in turn within the past two decades have been outmatched in public favor by the electric light, until the lighting of streets and public places is almost universally performed by the electric arc while the more modest incandescent lamp shines in stores and dwellings.

The popularity of the electric light must be ascribed to its convenience, its comparative safety, its freedom from heat and harmful fumes and the brilliancy of the arc, which gives the latter form of the electric light special advantages for certain situations. An electric lamp consumes less energy than an ordinary open gas lamp in the production of a unit illumination, but the operation of the electric lamp is little cheaper than that of the gas lamp, and its wastefulness, though less than gas, is still enormously great. The frightful waste of natural resources by civilized peoples in the latter part of the century just closed is illustrated by the losses involved in the production of electric light. A net ton of good bituminous coal may be assumed to hold an amount of available energy which is represented by 25,000,000 heat units. Not less than 22,500,000 of these heat units are lost in the successive processes of converting the available energy of the coal into the heat energy of steam in a boiler, into mechanical energy by means of a steam engine, and finally into electrical energy by means of a dynamo. Of this great loss, an overwhelming proportion is due to the steam engine. A small proportion of the remaining energy, which is now equivalent to 2,500,000 heat units, is lost in the transmission to the lamps, so that perhaps less than 10 per cent of the original total energy is delivered to the lamps. Here is a shining mote in the eye of the designer of the steam engine and boiler.

The waste of 90 per cent of our fuel which is caused by the extravagant process of generating electrical energy through the intervention of the steam engine and boiler, is sufficient to plunge all coal users who are acquainted with the limits of the world's coal supply into pessimism. But this is not the worst of the story! The electric lamp itself is the greatest spendthrift, as it converts into light only about 5 per cent of the energy delivered to it. Of the original 25,000,000 heat units in the ton of coal only about one-half of 1 per cent—or 125,000 heat units—are converted into light, and the great balance of 24,875,000 heat units which is equal to 99½ per cent of the energy in the ton of coal goes entirely to waste.

When gas and kerosene are burnt in our ordinary lamps, less waste is produced between the natural product and the lamps than in the electric system, but so much greater wastes exist in the open flames that the electric light is more efficient when considered as a whole. The coal gas which may be made from a net ton of good coal contains perhaps 7,000,000 heat units. The proportion of this energy which is converted into light at an ordinary burner is not more than 4-10ths of 1 per cent, or the equivalent of 28,000 heat units. This is less than one-fourth as much light from a ton of coal as may be gained through the electric light, but coke, tar and other by products are produced during the making of gas, and the difference is therefore not as great as might otherwise appear. The difference may be greatly reduced or even wiped out by the use of incandescent mantel burners with the gas.

The story of the electric lighting industry—big as it is and of incalculable value to the people—is, therefore, one of woeful wastes that are little if any less serious than those of competing methods of illumination and that cry out for correction. The Nernst lamp, if perfected, should result in a small saving—enough, if the lamp fulfills the expectations of its promoters, to increase the total efficiency by over one-third of its value, thus perhaps raising it to 7-10ths of 1 per cent. This, however, is but a drop in the total, and a revolution of the methods used at each extremity of the circuit must come with the march of progress during the twentieth century to avoid the ultimate exhaustion of the world's supply of natural fuel.

An industry that has grown like electric lighting from almost nothing to such magnificent proportions during the last fifth of the nineteenth century may during the first quarter of the twentieth be revolutionized and increased to still undreamt proportions. The primary generation of electricity for electric lighting through chemical action, and the artificial production of firefly light are day dreams of scientists. The equivalents of both are needed to give us an economical and a satisfactory artificial light. We are now in a period of the use of harsh lights—lights that are unbearable to the eye—and of extravagant lights. The demand of the hour is for diffused and uniform illumination by burners which convert the energy supplied to them into light with little loss. This demand may be filled when the equivalents of the day dreams are found. The firefly makes his light by the slow oxidation of fats; and what nature can do, man will repeat.

Electro-chemistry.

BY CARL HERING.

IN most cases the safest way to prophesy or to predict a growth or development, is to do it mathematically; that is, to plot the known results of the past and present, then draw a line, usually a curved one, through these points, and then prolong that curve, following as nearly as one can the same rate of change of curvature as that of the known part of the curve. Or in other words, find the law of development up to the present time and assume that this same law will continue in the future.

To apply such a method to electro-chemistry, however, would lead to absurd results, as the growth has been so rapid in recent years that such a curve, when prolonged, would soon become perpendicular to the base line instead of tending to become parallel with it, long before the line representing the end of the twentieth century is reached. Such a result indicates that there must be a point of inflection or change of direction of curvature at some time in the future. Or in other words, the development of electro-chemistry is so rapid at present that it cannot continue to grow at that rate for the next century, and the probabilties are that the present rate of development will continue, probably even at a faster rate than at present, but that in the course of time limits will be reached beyond which progress will be slower and in some cases practically impossible. But before such limits are reached it is probable that very important progress will be made and that electro-chemistry will become, if it is not so already, that branch of both the science of electricity and of chemistry, in which the greatest progress will be made and which offers the most promising field for research and invention. It is already the best field for graduates of good colleges to enter, provided they have a taste for that class of work and are willing to work hard and patiently, as there is much that is still obscure and not clearly described in text books.

Products, which not many years ago were rare specimens preserved in form of small fragments in sealed vials, and kept only in laboratories and museums, as rare curiosities, are now made electro-chemically by the ton. Others, which were not even known before, like carborundum, are now also made by the ton. A long series of new compounds, chiefly the carbides, have been discovered and studied electrically. Materials like graphite and the diamond, formerly found only in nature, are now made artificially, the former by the ton in the largest electrical furnaces in the world. Real diamonds are made, though at present only in microscopic specimens of no intrinsic value. Real rubies are made and small natural ones can be melted into large ones. Unfortunately diamonds do not seem to fuse, otherwise the same process might be applied to making large diamonds.

These few illustrations are enough to show what entirely new directions of development have already been opened up, and they are mentioned here to show how impossible it would be to prophesy what products or operations, heretofore unknown, might be discovered in the future. Could anyone have predicted such an entirely new discovery as the property of the Roentgen rays to enable one to see his own bones while in the body? No attempt will, therefore, be made here to predict what entirely new discoveries may be made in electro-chemistry during the next century, as such a prophecy would be idle and without foundation. This feature in a prophecy may be passed over by saying that the probabilities are that the large and increasing amount of research in this field will lead to some discoveries of heretofore unknown things, but what they are, or are likely to be, no one can predict. It will be more interesting and useful to confine ourselves here to the sphere of legitimate prophesying, and to endeavor to show what the probable developments will be of that which is already known, or of that which, with our present knowledge, seems likely

to be known. Also to endeavor to show what the limits are in some directions, beyond which no further progress is possible in those directions.

One of the directions in which improvement should and will be made—and the sooner it is done the better—is in properly formulating what is known, and in explaining, on the basis of well-founde l theories, the correct principles of this science; also in the adoption of uniform and correct terms, expressions and definitions. At present there still exists, to some extent, a state of chaos; many things are not yet clearly understood and others that are, are very unintelligently explained; tables of important constants are wanting or are very inaccessible or unintelligible. The same words and expressions are used differently. Mere hypotheses are advanced as theories, notwithstanding that they are still hotly discussed by eminent authorities. Chemists, as a rule, know too little about electricity, thermochemistry and molecular physics, while electrical engineers generally know nothing of chemistry and thermo-chemistry, and too little of molecular physics. An electro-chemist should be versed in all of these. Much time and money is lost in experiments and researches which a proper knowledge of these branches of science would have shown in advance to be fruitless. On the other hand, one who correctly understands all the principles involved, will often be led directly into the proper direction of research, and will not waste his time trying to get something that is impossible. One of the first requirements for the proper development of electro-chemistry is, therefore, that it be studied and practiced as a science.

Let us now review rapidly what is being accomplished in practice in the various branches of electro-chemistry and endeavor to find the direction in which progress is and is not likely to be made.

Electroplating is already a well-developed branch in which no remarkable developments are to be expected. The amounts of metal deposited are so nearly equal to the theoretical, according to Faraday's law, that the limit in this direction has been reached. But improvements in the details of processes are likely to be made, such for instance as getting better deposits and at greater current densities. Graham has shown, for instance, that with copper sulphate the current density may be enormously increased, even up to 3000 amperes per square meter, by extremely rapid circulation and yet the deposits will be excellent. The underlying principle of this is that the molecular layer of the electrolyte next to the cathode is being exhausted by the current of that which is being deposited, and unless it is as rapidly replaced by fresh solution, it will really be some other electrolyte which is being acted upon at the surface of the cathode, and hence the deposite will be affected. A more general recognition of this im portant principle in the future, not only in the deposition of metals but also in accumulators and batteries, will be likely to lead to important progress.

The great value of zinc plating on iron, for protection from rust, will be recognized more and more after satisfactory processes have been devised for obtaining good deposits of zinc, which is not easy. A good beginning is already being made, chiefly in England. There are a few other metals which, like zinc, are electro-positive to iron in nearly all ordinary solutions, and therefore protect the iron from rusting by a true electro-chemical action which tends to develop hydrogen at the exposed surfaces of iron; possibly processes may be found of plating with some of these instead of zinc.

Plating with aluminium would seem to have no great value as a process of plating, but this would mean that metallic aluminium was being obtained from an aqueous solution of its salts, and might be of great value as a method of producing the metal. While this seems to be a very difficult thing to do, it would be rash to predict that it never will be done. Processes for plating other metals onto aluminium, are greatly needed and will probably be found. Although numerous methods have been suggested, none seem to have come into use to any extent. The difficulty seems to lie in that transparent, glass-coating of the oxide which immediately forms on the surface and interferes with obtaining an adhesive coating.

Electrotypes for printing, made of iron instead of copper, are likely to come into more extended use, on account of the extreme hardness of electrolytic iron, which increases the lasting qualities and improves the definition. The difficulty lies in electroplating with iron to the required thickness. Copper plates are now plated with a thin coating of iron for very fine charts, bank notes, and work of that kind in which extremely sharp definition is desired.

The refining of metals, and their reduction from the ores electrolytically, is a rapidly growing field of very great industrial importance, and is likely to increase in importance as new processes are devised. Already a large part of the copper is refined in this way, not only to obtain a purer metal, but to separate out the other valuable metals like gold and silver, which are often associated with it in the ores. Electrolytic copper is not necessarily quite pure, as some other metals are also apt to deposit with it. Copper thus refined is already being deposited directly in the form of strong, tough tubes and sheets which can be used or worked directly without remelting, and in the future there is little doubt that not only copper but other metals also will be extracted from their ores, refined, and deposited in a form in which they can be used directly, by a single electrolytic operation without the use of any heat.

Although the limits to the amounts of metal obtained per ampere-hour, according to Faraday's law, are already very nearly reached, in many aqueous processes at least, there still is a possibility with some metals, of obtaining a much larger amount per ampere-hour, than is usual, by using salts in which the valency of that metal is lower. For instance, the possible amount of copper obtainable per coulomb from cuprous salts is just twice that from the more usual cupric salts, which, if the voltage is the same, would reduce the power required per ton of copper to one half, and might also decrease the size of the whole plant in the same proportion.

The artificially-maintained high price of copper will induce large consumers to extract their copper themselves from the ores, which might pay in the future even with poor ores. Already mines of poorer ores, which had been abandoned, are being worked by electrolytic processes.

It is likely that zinc will in future be refined and extracted electrically from its ores, although at present the outlook does not seem to be very encouraging. The demand for a pure zinc is not so great as for some other metals; this, however, may be due to some extent to a lack of appreciation of the qualities of pure zinc. It is probable also that zinc will in future be extracted from ores which exist in large quantities, but are not worked now because it does not pay to do so by the old processes.

The reduction or extraction of other metals by electric means is likely to come into use more and more, as fast as processes are invented for doing so. In many cases it will not be difficult to devise better processes than the present which are almost universally thermic, as the efficiency of most processes involving heat is generally very low, at least in air combustion furnaces as distinguished from those in which the heat is generated electrically. Moreover there are other indirect advantages to be taken into consideration, which may outweigh the power efficiency to such an extent that the latter may even be poorer and yet the process, as a whole, be cheaper. It may not be rash to predict that even iron may at some future time be extracted electrically; the energy efficiency is not the only consideration, there being others like the purity of the product, the value of the by-products, the use of water power near the mines, which saves the transportation and handling of the coal or the bulky ore, the diminution of the size of the plant, etc., all of which should be taken into account.

Metals, as such, generally have more potential energy than their oxides or salts, and in reducing the latter, energy is not only required to overcome resistances, but some of it, and sometimes very much of it, is absorbed as it were, or stored, in the metal. Most of the energy of primary batteries, for instance, originally came from the coal used in reducing the zinc from its ores, and was stored in the zinc. There is therefore a theoretical limit to the diminution of the electrical power required to reduce a ton of metal from its salts in the ores, below which it will never be possible to go. This, of course, applies only to ores consisting of the salts or oxides of the metal and not to those containing the metals in their native state, as with copper and gold. For zinc, reduced from its oxide, this limit is a little over 2000-hp hours per long ton of metal. The minimum possible cost will therefore always be the cost of that much power.

Gold extraction processes, like the cyanide, will no doubt come into more general use and are already so much superior to the older processes that the tailings of gold mines are now being profitably worked over again by this electrical process. It is even possible that within the next century the electrolytic gold extraction processes may be perfected to such an extent as to make it profitable to work ores which are very poor but exist in very large quantities and are easily handled. The clay around Philadelphia, for instance, contains gold to such an amount that every brick made of it has enough gold in it to make two square inches of gold foil. The seawater is an enormous gold mine, which even a trust could not monopolize. A long ton of sea water, at least near Australia, contains about 0.07 grains of gold, at which rate the oceans, which are estimated to consist of 400,000,000

cubic miles of water, contain about 7,000,000,000 tons of gold, the value of which is about $4,900,000,000,000,000. Vast though this is, it would have to be a very cheap process to pay to get it out, on account of the enormous amount of raw material which would have to be handled. The gold will therefore probably stay there, but if in the course of the century a process should be found to pay, it will most likely be an electrical one. It might become practicable to extract other useful ingredients from the sea water, such as soda, chlorine, bromine, iodine, etc., in which case the gold would come out as a by-product. But the outlook is not promising, except for promoters like the Rev. Mr. Jernegan, who used methods which do not come under the heading of electro-chemistry.

Alkalies and their usual electrolytic mate, chlorine, are now being made in enormous quantities from ordinary salt. Already the electric process is replacing the older chemical ones, there being about 30 plants in operation, all started during the past ten years; it is likely to continue to do so more and more. The chlorine is converted into a bleaching and disinfecting solution or compound. Paper pulp and textile fabrics are now being bleached in large quantities by electrolytic bleach very effectively and with less destruction of the fibres, and the practice is likely to increase.

Often one of the most difficult obstacles to be overcome in the introduction of electric processes, is the mental inertia of those who have for years and sometimes generations, used the old processes, and who are opposed to trying anything new. One of the developments in the new century will be the weeding out of such antiquities by the natural process of competition with their powerful enemy, enterprise.

Chlorate of potash is now produced very largely by electrolysis, the existing plants being already capable of supplying the demand of the whole world.

There are many other directions in which the use of electro-chemical methods may be reasonably expected. Sewage may be disinfected, although at present the prospects are not very bright, on account of the expense. Oxidizing reagents, such as chromic acid, which are largely used in the industries, may be reoxidized very efficiently by electrolysis. Many organic compounds used in the arts and industries, including aromatic compounds, can be produced electrically. The very slow process of tanning hides can be greatly hastened by electric means, although it does not yet seem to have emerged from the experimental stage. The slow ageing process of wines and spirits may be artificially hastened by electric means. Whether such processes are in use, will probably not be known by any but those who make use of them, as imagination and taste are closely associated human qualities. The electrolytic engraving of steel dies, which can now be done much cheaper than by hand, is another illustration of the varied applications of electrolysis which may be expected in the future. The electric production of that useful substance ozone, by spark discharge, or possibly by some better means, is another possibility of the future, although at present the prospects do not seem very encouraging on account of the very poor power efficiency of those processes, and difficulties encountered in the apparatus.

Besides the electrolysis of aqueous solutions discussed above, there is a very promising field which, though not as varied in scope, may yet be of considerable commercial importance; it is the electrolysis of fused materials. On account of the greater difficulties involved, and in most cases the poorer energy efficiency, it will probably be applied only in cases in which aqueous solutions cannot well be used, as for instance, for the production of metallic aluminium, sodium, potassium, magnesium, etc. This is a field, the development of which has only just begun, and it seems fair to predict that in limited directions some important developments may be expected.

Some of the metals and products produced in this way and by the closely allied electric furnace, may be said to be great stores of energy and much better than coal, in that their energy can be more efficiently utilized. Metallic aluminium, for instance, is an excellent and very energetic fuel when burnt with the oxide of some other metals, and can be used very effectively for certain metallurgical operations; it is already used in this way, for instance, for the reduction of metallic chromium and manganese for the iron industry, with a good abrasive material as a by-product. A more extended use of such artificially-produced fuels, of which calcium carbide is another, may be expected, although their application is, of course, limited.

One of the industries which is already flourishing, but in which there is much room for perfection, is the reduction of aluminium from its ores. All of the metal which is now produced, amounting to between 2000 and 3000 tons yearly, is obtained by electrical processes. It is already beginning to replace copper for bare conductors, due to the artificially maintained high price of the latter material. At present it takes one horse-power for almost a whole day to produce a pound of aluminium, while theoretically it requires only about 4½ horse-power hours to reduce a pound from its oxide, and probably nearly the same for other ores of this metal; its theoretical minimum possible price will therefore never be less than the cost of that much power. It may even become possible in future to use some of the ordinary rocks as aluminium ores, most of them consisting chiefly of aluminium silicates, instead of importing special ores. An advantage of this might be the simultaneous production of some by-product, of value.

Sodium peroxide is one of those materials which was formerly scarcely known, and is now made electrically in large quantities. No one can predict what other new materials may be made cheaply in the future, but it is safe to expect that others will be produced, and that new and important industrial applications will be found for them.

Some of the most important progress in the industrial application of electro-chemistry may be expected in the use of the electric furnace, as this is a comparatively new field. The resistance furnace enables a very localized temperature to be produced of almost any degree, limited only by that which the receptacle will stand and that at which the materials vaporize. Probably all materials, even those like porcelain and fire brick, become fairly good conductors at a high heat, so that all materials to be acted upon in such a furnace may be used as the heat-producing resistance itself. The temperature of the arc furnace is practically limited to that of the vaporization of carbon, between 3000 and 4000 degs. C, which is high enough for most purposes; the atmosphere in it is not only strongly reducing on account of the carbon vapor, but even tends to form carbides with most metals. Electrolytic action on the fused materials, when not simple elements, is likely to occur in both, unless the current does not pass through the material itself. Some of these properties will be made good use of while others are objectionable.

The field opened by the electric furnace is such a new and wide one, that it is difficult to prophesy what the developments will be likely to be; but in general it may be said that whenever the above-mentioned qualities are important requirements, and the expense of the power not too great, the electric furnace will replace the others. It is even likely that, notwithstanding the poor efficiency of the steam engine, it may in some cases be cheaper to use electric heat on account of the still poorer efficiency of some gas or coal furnaces. Moreover, the cheapness or efficiency of the power is not always the first consideration, as there are other advantages which will often outweigh the question of the cost of the power. It is probable, therefore, that the electric furnace will find many applications in the future, even though the actual cost of the heat is much greater than with gas furnaces. They will be likely to be used as day loads for lighting stations or night loads for traction power houses. Undoubtedly new and useful compounds will be produced by means of this furnace and operations will become possible, which before were not.

Calcium carbide, which owes its existence to the electric furnace, is now being made in such large quantities that over-production may result. One plant at Niagara Falls is said to turn out the enormous amount of 100 tons per day. A development that is much needed in the carbide industry is to find markets for all that is made. One of the unpleasant prospects is that a cheaper non-electrical process of making it may be discovered. The figures concerning the energy required differ rather widely, but roughly, about 4000-kw hours are required to produce a long ton of the carbide. The theoretical amount seems to be still in doubt. This material is also a storer of energy which is abstracted from the furnace and can be given out again at any desired time. It is likely that other carbides, which may be as useful as this one, will be found in the future.

Many other chemical products, now made by purely chemical or thermic methods, will in future be made by means of the electric furnace. Phosphorus is already made in large quantities. Artificial graphite is now being made at a rate of nearly 200 tons annually in the largest electrical furnaces in the world, 50 ft. long inside, and still larger ones are under construction. It is intended to make it direct from coal and at a price below that of natural graphite, an important intermediate step being the formation of a carbide.

Carborundum, the carbide of silicum, was discovered with the electric furnace, and is now made by the ton in some of the largest furnaces in the world. The annual production is nearly 800 tons.

With the increasing use of the electric furnace, other equally, or possibly even more useful, products are likely to be discovered in the future. The writer recently had occasion to measure the output and efficiency of a very good electric furnace for the production of metallic

arsenic from an ore which is generally considered worthless. Moreover, the matte which remains may then be worked for the gold in it, while the original ore was worthless as a gold ore. In general it is probable that with the electric furnace many ores, which formerly were too poor to work, will in future be worked with profit.

One seems justified in predicting an important future for electro-chemistry, from the fact that there appears to be no well developed and established electro-chemical process, which has as yet been superseded by a non-electrical one, while the latter has often been superseded by the former. This, however, will probably not always be the case.

In the accumulator field, there seems to be no promising outlook for anything revolutionary. Recently there has been developed a modified form of storage battery which might be said to be a primary battery in which the materials consumed are afterwards regenerated again by an electric process, but not in the battery itself. For some purposes this has advantages over the usual accumulators. This opens up a new field in which improvements may be expected in the future.

For primary batteries, strictly so-called, the outlook does not seem to promise anything more than small improvements.

There are, of course, possibilities of finding within the new century the long-looked for primary battery in which carbon or other cheap natural battery fuel is burned cold, or even hot, giving off its energy as an electric current with a possibility of obtaining from 6 to 10 times as much energy as at present. If a practical form of it is found, the steam engine, and even the gas engine, may have to go, together with the dynamo; but there seem to be no prospects at present of the solution of this very important problem in this way. The difficulty is by no means only at the carbon electrode, but largely also with the other which furnishes the oxygen.

It is probable, however, that the same ends will be accomplished much sooner by an indirect method, in which the consumed materials of a primary battery will be regenerated by means of the energy of coal; the materials consumed in the battery are then only the carrier of the energy of coal to the cell, and can act as such a carrier repeatedly and efficiently. But even by this method this important problem will probably not be solved in the near future. Moreover, it must not be forgotten that a method which operates will not necessarily replace present methods, as mere efficiency is not the only requisite. The apparatus must at the same time compare with the steam or gas engine in first cost, cost of attendance, depreciation, floor space, etc.

Although many inventors have been working at this problem for many years, we seem no nearer the solution now than we were before, and it may be many years before it is solved. The numerous partial solutions which have been offered, sometimes with great eclat, have either been based on fallacies, much to the humiliation of the inventors, or they were impracticable.

There is still another possibility of the future which might be mentioned here, although it belongs more strictly to electro-physics than to electro-chemistry. It would be even more revolutionary in character than any of the others. A careful study of the electric phenomena in vacuum tubes has led certain prominent English physicists to the interesting conclusion that atoms, which heretofore were the smallest particles known, were capable of sub-division. This implies a recomposition of these smaller particles into different atoms, or in popular language, the possibility of the transformation of one metal into another. Coming from such high authorities, the statement that atoms can be decomposed, startling as it is, can be criticized only by their peers. Let us wait developments; the new century will bring them.

Electricity in the Last Century.

In 1820 Oersted discovered the connection between electricity and magnetism, and in 1825 William Sturgeon, to whose name sufficient honor was not paid, described what was literally the foundation of electrical engineering—the electromagnet. This was applied to the purposes of telegraphy—in America by Morse and in England by Wheatstone and Cooke. Finally, Faraday, arguing that, if electricity could produce magnetism, the converse should be true and magnetism should produce electricity, invented the first mechanical method of generating electrical currents by rotating a coil of wire in such a way that it cut the lines of force proceeding from a magnet. The magneto-machine thus made was improved by Wilde, Gramme and others into the dynamo of to-day.—PROF. S. P. THOMPSON.

Wireless Telegraphy.

BY ARTHUR V. ABBOTT, C. E.

TO the five ages of Hesiod and Ovid, the historian of the future may well add the century just completed as the age of electricity. Never has the world witnessed a transformation so wonderful, so far reaching or so complete as has been effected by the commercial applications of this form of energy, that have originated during the latter half of the nineteenth century. Sixty-five years ago not a dollar was invested in electrical industries, while to-day the enterprises that more or less directly involve its use, count capital by billions.

To the art of electro-plating belongs the honor of being the first development of electricity, for this invention antedated by possibly a half dozen years, that famous experiment of Prof. Morse in the laboratory of the University of New York, that set electrical arachnids spinning metal cobwebs over the globe so industriously that we can now accept Puck's challenge and put a girdle around the world in considerably less than forty minutes. Though electro-metallurgy is of great value to the human race, the electrical transmission of intelligence vitally affects the interest and welfare of a larger number of mankind than any other invention, save that of printing, and as the telegraph is in the foremost van of electrical development, it is not surprising that the closing year of the first century of electricity should witness a discovery that will certainly profoundly affect the present methods of transmitting intelligence, even if the optimistic prophecies regarding Hertzian waves are not fully realized.

Historically, the electrical discoveries which have made the so-called wireless telegraphy possible, commenced with Lord Kelvin's announcement in 1853 of the oscillatory character of a Leyden jar discharge and the formulæ for determining the time and amplitude of the waves when the capacity, inductance and resistance of the circuit are known. Some eleven years later, Maxwell followed with his brilliant mathematical demonstration of the electro-magnetic origin of light. In 1888 the classic experiments of Hertz demonstrated the physical existence of the previously mathematically predicted waves; showed means for producing them, and proved them in all respects. save speed and amplitude, identical with other ether waves. The apparatus possessed by Hertz to determine the presence of such undulations were, however, so crude that he was only able to show their propagation over the short space of a university lecture room, and thus their availability for the transmission of messages did not occur to him.

In 1890 Branly proved that electrical radiation exercised a peculiar influence upon the molecular condition of pulverized bodies, whereby in many cases the conductivity of a powder was much changed, thus discovering a method of detecting electrical oscillations of greater sensitiveness than existed at the time of Hertz. In 1893 Dr. Lodge so aptly named the Branly "Radio-Conductor" "The Coherer" that this cognomen has become of universal application. Other French and Russian scientists repeated the Lodge and Branly experiments, provided the coherer with automatic means of maintaining sensitiveness and suggested the use of a vertical wire or "Feeler" to aid in the collection of sufficient energy to produce coherence. Prior to 1895, however, Hertzian waves were merely laboratory experiments and even Dr. Lodge is quoted as doubtful of any extensive practical application. But now Mr. Marconi appears on the scene, a skilled mechanician, he presents that indispensable quality of good common sense that seems necessary to place the results of the investigator within the grasp of the multitude. Without any new invention, simply by excellent mechanics and careful investigation, feeling the way, step by step, he succeeded in so developing the apparatus of Hertz, Branly and Popoff, as to startle the world by demonstrating the possibility of transmitting space signals over scores of miles. In 1897, with vertical wires 100 ft. high, nine miles were covered, while last year with 140-ft. masts, nearly 100 miles were spanned. In 1898 Mr. Marconi announced the discovery, that the distance over which signals are transmissible varied as the square root of the height of the mast, but his most recent experiments point to even a greater ratio of range.

Other experimenters have achieved similar results. In 1897 Dr. Slaby, using a kite, transmitted signals over thirty-five miles, with a 900-ft. wire. The succeeding year Marconi reported the international yacht races from a steamer following the schooners, sending the signals to a station located at Sandy Hook.

During 1900 considerable progress, both in theory and practice, may be reported. It has been shown that the coherer will operate only when the difference of potential applied to its terminals exceeds a certain amount termed the "critical voltage." To receive messages then, the vertical wire must be looped by a sufficient number of lines of force to produce this critical potential, and in order to maintain the coherer in a sensitive condition and effect decoherence, the potential of the local battery, plus that due to inductance of the local circuit, must not reach the critical voltage. Here, then, lie the limits of the receiver. By using filings of a non-oxidizable metal in a vacuum and the use of a telephone as a receiver, the critical voltage may be reduced to its lowest terms. While Mr. Marconi, by the addition of a peculiarly wound induction coil, or step-up transformer, raises the potential difference delivered to the receiver by the mast to its highest limit and asserts that thereby the transmitting distance of signals may be multiplied sevenfold.

The researches of Prof. Chunder Bose show that there is a much deeper significance in the phenomena of the coherer than can be accounted for by the hypotheses of Dr. Lodge. Prof. Bose shows that nearly all substances are affected by electrical radiation and divides bodies into two classes, those which he terms positive having their resistance decreased when subjected to Hertzian waves, while the remainder are negative substances, increasing in resistance under similar conditions. Very far-reaching is this discovery, for it immediately opens to view the possibility that with a certain mixture of positive and negative substances any degree of sensitiveness can be arranged, and suggests the possibility of making the coherer automatic in action, thus relieving it of one of the most troublesome and annoying features of the present method of decoherence.

But what is the actual status quo of wireless telegraphy as a commercial art, and what are the probabilities for the future? Both in this country and in Europe, Mr. Marconi has demonstrated that readable signals may be sent over a space of nearly a hundred miles. Other experimenters have confirmed these results. The apparatus is easily manipulated, is reliable, does not require extraordinary skill to operate, and is not excessively expensive in cost of construction. As yet the range is limited to 100 miles, nor has more than a third of this distance ever been covered, exeecpting at sea, for it is curious to note that all attempts on land have so far been failures when pushed over a space exceeding a few miles. The squadrons of the world have proven the possibility of signalling under all conditions of naval manœuvers, and there are several experimental stations at work at sundry points on the English coast with apparent success. But when the records are examined for reports as to commercial business and when one looks for the number of instruments operated for revenue and the returns therefrom, not a single instance is to be found. The African war would seem to have presented a peculiarly attractive opportunity to demonstrate the value of Hertzian telegraphy. Instruments and operators were shipped to the front, but not a message was transmitted, because, forsooth, no masts were included in the outfit, and it was alleged that the African meteorological conditions were so anti-British that when there was wind enough to fly a kite at one station, there was none at the other, some thirty miles away. Meanwhile an old-fashioned rival of wireless telegraphy (the heliograph) flashed its nightly tidings during all the weary months of the siege of Ladysmith. As the transmitting station is the center of a spherical wave, it follows that a receiver located at any point on the successive surfaces as the wave progresses may be affected. This fact has been urged as a serious objection to radiant telegraphy, as secrecy is impossible. For this reason it is doubtless somewhat easier to obtain a knowledge of wireless signals than those transmitted by other methods, but saving the use of a cipher, there is no method of telegraphing or telephoning with which an expert eavesdropper cannot readily become acquainted, and cryptographers are always busy inventing new codes to replace those which their equally ingenious and too curious opponents have deciphered. A much more serious consequence of the spherical wave, is the enormous expenditure of energy in proportion to the effect on the receiver. When it is remembered that the energy at the emitting station must vary as the square of twice the distance between the oscillator and coherer, the glibness with which the ease of signalling from London to New York is discussed, recalls the Solomanic aphorism regarding "He that answereth a matter before he heareth it." Further, as the radiation from any source may impinge upon any receiver located within the sphere of its influence, a hostile transmitter may be easily operated and the injection of a few meaningless symbols throw into hopeless confusion all of the receivers in its neighborhood. In point of speed Hertzian telegraphy again finds itself sadly handicapped. Even in expert hands it is slow in comparison with other methods. The sending key must transmit the heavy currents needed to excite a powerful induction coil; there is also the inertia of the oscillator and sluggishness of the coherer and decohering mechanism, so a dozen or fifteen words per minute becomes phenomenal and on the average rarely more than eight or ten are achieved. Mr. Gradgrind would probably summarize the present condition of wireless telegraphy something as follows: A limit of 100 miles at sea and one-third of that on land. The impossibility of secrecy excepting by code. The impossibility of operating more than one station simultaneously within the limits of a single receiver. The helplessness of the receiver when subjected to hostile radiation. The probable average speed of less than a dozen words per minute, with the expenditure of an enormous amount of energy. To offset, there is only the saving in the cost of line construction between the two stations, which ordinarily would be cheap in comparison with the royalty which the owners of the Marconi patents are rumored to charge.

But what of the future? Wireless telegraphy is only a few years old and in the natural course of evolution may develop as usefully as the telegraph or telephone. As electric waves differ only in speed and amplitude from others, they obey the same laws of reflection and refraction. Therefore it should be possible to concentrate them and produce an electric beam by means of proper mirrors or lenses, in the same manner as a searchlight ray is obtained. It seems possible that the circuits in the receivers and oscillators could be so adjusted that they should only mutually respond to each other like a pair of sympathetic tuning forks. Theoretically all this is within the nature of things and if achieved would go far towards removing the present impracticabilities. Mr. Marconi claims, it is said, to have solved these problems and to have produced a syntonic receiver and transmitter that only respond to the particular waves emitted by the one and that are intended for the other. He also, it is claimed, has produced a projecting apparatus that emits a well-defined electric beam and has replaced the vertical receiving masts by an equally efficient and more compact collecting cylinder. As yet, however, these are nothing but the merest rumors, unless a very indefinite letter from Prof. Fleming may be regarded as confirmatory evidence. Possibly the first year of the new century will reveal some discovery that may be a panacea for all of the "ills which Hertzian signalling is heir to," but from the cold and calm standpoint of present facts the way appears to be tedious, the road hard and difficult and the goal a long way in the future.

The Storage Battery.

BY AUGUSTUS TREADWELL, JR.

THE early history of the storage battery is coincident with the early history of the voltaic pile. In 1800, the year made memorable by Volta's discovery of the galvanic battery, Nicholson and Carlisle found that a current from Volta's cell could decompose water. In 1801, Gautherot found that if the platinum or silver electrodes of a voltameter were connected together, after having a voltaic current passed through them, that a secondary current of short duration would flow. Erman found that the positive pole of such a cell was the pole which had been connected to the positive pole of the battery. In 1803 Ritter observed with gold wire the same phenomenon as Gautherot, and constructed the first secondary battery by superposing plates of gold, separated by cloth disks, moistened with ammonia.

Volta, Davy, Marianini and others added somewhat to the knowledge on the subject, and in 1837 Schoenbein found that peroxide of lead could be used in secondary batteries. Sir William Grove next came forward with the discovery that metal plates, with a layer of oxide on them, acted better than the plain metallic plates, and Wheatstone and Siemens found still later that peroxide of lead was the best for such purposes.

In 1842 Grove constructed his famous gas battery, in which the e. m. f. came from the oxygen and hydrogen evolved in the electrolysis of water acidulated with sulphuric acid. By means of 50 such cells he obtained an arc light. Michael Faraday, when electrolyzing a solution of lead acetate, found that peroxide was produced at the positive and metallic lead at the negative pole, and in his "Experimental Researches" he comments on the high conductivity of lead peroxide

and its power of readily giving up its oxygen. Although he made no apparent use of this discovery, it may be considered as the next important step in the development of the storage battery. According to some authorities, Wheatstone, de la Rue, and Niaudet were well aware that peroxide of lead was a powerful depolarizer, but nobody appears to have made use of this fact until 1860, when M. Gaston Planté constructed his well-known cell with coiled plates. M. Duerlir claims that Sinsteden used the secondary action of lead in sulphuric acid in 1854. Although it is well known that Sinsteden did notice the peroxidation of a lead plate in sulphuric acid, we have no further proof that he put it to any practical use.

Planté's researches extended up to 1879, and practically determined the state of the art. As to the theory at this time, it may be stated that Clerk Maxwell, although the leading electrician of his time, speaks of the storage battery as storing up a quantity of energy in a manner somewhat analogous to the ordinary condenser; hence the use of the word accumulator for storage battery. In 1879 R. L. Metzger, of Germany, did away with the tedious forming process by mechanically applying the active material. This important discovery was not, however, generally known until 1881, when Camille Faure obtained important patents concerning this method of shortening the time of formation. Charles F. Brush, working independently of either Faure or Metzger, arrived at the same result, and the United States Courts have decided, after long litigation, that to him belongs the priority of invention in this country.

It is claimed by R. Jamins, in his book entitled "Recherches sur les Accumulateurs Electriques," that Planté himself was the true discoverer of the mechanical application of the oxides, or, in other words, the real inventor of the pasted plate.

That this view is shared by Jablochkoff is shown by his application for British patent No. 1745, date April 22, 1881, in which he states that M. Planté proposed to apply the active material mechanically to the support plate.

It should be noted, however, that Mr. Bedford Elwell, the translator of Planté's "Recherches sur l'Electricité," makes no mention of any process for mechanically applying oxides to storage battery elements, nor were the alleged troubles referred to in his translation.

The first United States patent ever granted for storage batteries was granted to George C. Percival in 1866, No. 53,668. This battery consists of a wooden box, divided into two parts by a porous partition and filled with a suitable conducting powder, moistened with dilute sulphuric acid; two lead plates placed on opposite sides of the box constitute the terminals.

The work of Fauré practically ends the history of what is termed the lead-lead battery, the battery of to-day, if not of the future. No history of the lead-lead battery is, however, complete without mentioning the work of Marchinay, Maxwell-Lyte, Andreoli, Payen and Herbert Lloyd. To these men is due the credit of conceiving and bringing into practice the use of lead chloride for accumulator elements. This compound has done much to popularize the storage battery and show to electrical engineers the absolute necessity of a battery of accumulators in lighting and power work.

Besides the lead-lead battery, however, are those in which one or both electrodes are of some other metal than lead. This includes the lead-copper, lead-zinc, copper-zinc, and that miscellaneous set which is intended to overcome all the disadvantages of the former types.

The principal advantages of the lead-copper group are their economy in construction and the fact that they retain their charge very satisfactorily. The voltage, however, is low, averaging about 1.25, and the capacity per unit of weight small.

Reynier, Mason, Sutton, and Erving are the principal workers in this field of batteries, the first of this group appearing about 1880. The electrolyte for this type consists usually of copper sulphate, although in some cases ammonia and acid bisulphate of mercury are used.

The lead-zinc battery is economical in construction and is the lightest, theoretically, of all types. The capacity in watt-hours per pound of working substance is more than 50 per cent higher than with the lead-lead group. The e. m. f. is the highest of all the groups, averaging about 2.5 volts.

Wheatstone, in 1843, was the first to advocate the use of zinc instead of spongy lead for the negative electrodes. The problem was, however, apparently dropped until 1882, when Emil Boettcher produced a practical cell. Reynier, Tamine, Epstein and Main and Meserole are the principal workers to date with this type of battery. Alkaline zincate genus—These cells, which have been used mainly for traction purposes, have given very fair results. The voltage is, however, low, averaging about 1.1 volts. They possess the disadvantage common to all batteries that do not use lead for the electrodes, that the metal is eaten away by the chemical and electrolytic action. This, many claim, is counterbalanced by the fact that they are very easily and cheaply constructed.

The principal workers in this field are Lalande, Chaperon, Edison, Thomson and Houston, Desmazure, Commelin, Schoop, and Waddell & Entz. The Waddell-Entz battery has been very extensively used, more than other batteries except the lead-lead type.

Darrieus, Platner, Kalische and Marx are among the historical names of those who branched out from the beaten lines of experiment and produced excellent results with other metals.

Before going further, it might be well to briefly classify the storage batteries which are in the market to-day, with a prominent example of each type.

The first and most prominent type is the lead-lead battery, divided, of course, into the Planté and Faure types, each of these types being again sub-divided according to the improvements in each, as follows:

A.—The Planté: 1. Chemical or electro-chemical. In this type some special forming bath is used. The Willard and Gould batteries are the best examples of this class.

2. Mechanical. Either some special form of casting is used, or the plates are passed through a die which tends to materially increase the surface of the electrode. To this belong the Ohio and American storage batteries.

3. Electrolytic. Finely divided lead is obtained by the electrolysis of a lead salt, or a lead salt is formed into a plate and then reduced to metallic lead. The Chloride plate is the best example of this class.

4. Plates composed of solid active material. Percival's battery and Fitzgerald's lithanode plate belong to this group.

B.—Fauré: I. Reduction of weight. In this the plate is either composed of some alloy of lead, or of some non-conducting material. The Hagen and Hatch batteries belong respectively to the two divisions of this type.

2. The retention of the paste or active material. This is accomplished either by grooves or by perforations of the grid, or the entire plate is enclosed in a perforated conducting or non-conducting material. Of these types the Brush and the Tudor represent the first method, the E. P. S. the second, the Tommassi and Ford-Washburn the third, and the Pumpelly and Hess batteries the fourth.

3. Provision for better contact between the support plate and the active material. This is usually accomplished by rubbing the support plate with carbon, or the addition of carbon to the active material, or the support plate is partially oxidized. Paget and Tudor are best examples of these methods.

4. The prevention of buckling. Reckenzaun and Hering illustrate this the best.

C.—Lead-copper. Sutton.

D.—Lead-zinc. The River and Rail Battery.

E.—Alkaline-zincate. Waddell-Entz.

F.—Miscellaneous. Marx liquid battery.

Storage batteries are without question to-day an important factor in central station work and in regulation at power stations. The high peak which appears in load diagrams, and which represents the period of maximum demand, the small night load, and the great variations and fluctuations of load on power circuits, especially on those circuits which supply trolley lines are among the worst difficulties which confront station managers, and for these and many other purposes storage batteries are rapidly becoming universally recognized as being an almost indispensable auxiliary. In large alternating current stations, such as that of the Brooklyn Edison Illuminating Company, at Bay Ridge, storage batteries are used for the excitation of the fields of the alternating current generators. For central station work storage batteries find their principal uses in carrying the peak of the load, in carrying the entire load at minimum hours, in acting as an equalizer or reservoir and for the equipment of annex stations.

The period of maximum demand varies anywhere from 1 to 5 hours per day, and were it not for the use of accumulators, generators would have to be supplied which would be able during this time to carry the peak and yet which during the remainder of the day would be called upon for only a small fraction of the total load, thus causing a great loss in efficiency.

It seldom occurs in a properly managed station that the period of minimum demand is long enough to allow of the laying off of one shift of men and the drawing of the fires. In most American stations this period seldom amounts to more than four or five hours, so that

as in the case of the Boston Edison station it is found more economical to charge the battery during this period than to shut down the engines and generators entirely. It is in the capacity of an equalizer or reservoir that the storage battery finds its greatest use in station work to-day. Manufacturers will to-day guarantee that the efficiency of a battery, when operated in parallel with the generators, will exceed 80 per cent, and will willingly undertake a maintenance contract for a long term of years upon the basis of 5 per cent. The small loss in efficiency due to accumulators is more than made up by the greatly increased efficiency of the steam plant. In Hamburg, moreover, the loss in the batteries is only 1.2 per cent of the average amount of electrical energy generated during the year.

For the equipment of annex stations a large field for the use of batteries is offered, for otherwise an entirely separate station would have to be installed at this point, or the manager would be compelled to run heavy feeders to the centre of distribution. The latter alternative would mean heavy losses in the feeders, and large interest charges for the conductors. By the use of batteries, higher tension currents would probably be employed, which would necessitate a small amount of copper in the conductors.

Perhaps the best example of the value of the accumulator as an equalizer that has come under the notice of this writer occurred during a test of the storage battery plant in the building of the Commercial Cable Company in New York. In this plant the battery is run in parallel with the generators, which supply together the elevator and lighting service. The battery thus assists in taking the load by meeting the sudden demands of the elevator service, and being charged when the load drops off. During this test the battery current jumped from 350 amperes on charge to 550 amperes on discharge, thus giving a variation of 900 amperes in the load, and yet during this the voltmeter on the lighting circuit did not show a variation of half a volt, which, on a 240-volt circuit, as in this case, means a variation of less than one-fourth of 1 per cent.

A large number of experiments have been made looking to the adoption of storage batteries for traction purposes. As yet, however, but little success has attended these efforts, due in the main to the extreme weight of storage batteries, and to the high cost of maintainance. Both of these factors are constantly being reduced and the author looks for a battery in the near future that can be used on cars with success. It should be remembered, however, that the large number of failures that have attended all efforts to operate a successful storage battery street car service is due not so much to defects of the battery as to outside influences which have nothing to do with the battery.

For example, in the case of the most recent failure, that of the Chicago Electric Traction Company, which has within the past three months been changing over to the overhead trolley system, the line was long and the district through which it ran was but sparsely settled. In this way the passenger receipts were small and the company was compelled to operate more than one charging station, thus doubling the fixed and operating expenses, while with the trolley but one power station will be required. When the road was installed it was the expectation of the officers of the company that that section, because of its advantages, would be quickly built up.

In the storage battery road in Paris, on the other hand, the road is a success. In several cities in Germany the combined trolley and storage battery is being used with considerable success, the battery being used in the denser portions of the city, while the trolley is used in the outside districts.

The Metropolitan Traction Company, in New York, has installed storage battery cars on its Thirty-fourth Street line, which are, from all accounts, meeting with considerable success. This line is the more interesting from the fact that the same company is operating compressed air cars on the Twenty-eighth and Twenty-ninth Street line. These two lines are very similar in character and can therefore be easily compared.

The writer has been informed by a number of persons intimately connected with the company that the latter experiment, while successful, does not in that way compare with the storage battery line, the results of which have been most gratifying. In justice to both, however, it should be remembered these two lines have been operating too short a time to enable the company to determine accurately which will be the most successful in the long run.

The most recent use to which storage batteries have been put, and in which the success is most astonishing when the number of traction failures are considered, is that for automobiles. The electric cabs which are now operating have shown the most gratifying results from the start and are everywhere meeting with ever increasing favor.

A number of automobile companies are operating in the large cities of the United States and Europe, and new companies for this purpose are constantly being formed. In fact, it is due to the storage battery that the automobile has met with such favor, and that carriages operated by other means than electricity are constantly being exploited.

In regard to the future of the storage battery, it is probable that for central and power station work the battery will be so constructed as to give heavier discharges for longer periods than at present. Of course, one of the means of accomplishing the result will be by materially increasing the working surface of the plate, although that alone could not accomplish the result. The plate must also be so constructed as to permit heavy discharge rates without driving out the active material. The plates will also be so constructed that the danger of buckling, if not absolutely prevented, will at least be reduced to a minimum. While not of such great necessity in central station work as in other lines, the plates will be so constructed as to permit of much higher charging rates and consequently decreased time of charging.

For automobile and traction purposes, however, the battery will be materially lightened. It is probable that this will be accomplished by using some alloy of lead for the plate instead of the lead-antimony plate now used. This will permit of a much thinner plate being used without impairing its working qualities. As in the case of central station batteries, improvement will also go on along the lines of increased discharge and very greatly increased charging rate. Batteries will also be constructed with much increased capacity, which will enable carriages to have a much larger sphere of usefulness. While many experimenters believe that storage battery plates will be constructed of some other metal than lead, this does not seem probable; at least in the near future, for the reason that metals are dissolved by the electrolyte, while lead, because of its coating of sulphate, is insoluble. In all other cells in which some other metal than lead is used, the changes that occur with each charging are relatively so large that they rapidly deteriorate and require constant attention and repairs. Lead alone of all the metals forms a sulphate that is practically insoluble and unacted upon by dilute sulphuric acid, and it also forms a peroxide having good electrical conductivity, and equally unaffected by the liquid. The compounds formed when other metal than lead is used in any practically possible solution now known are all to a large degree soluble.

With the improvement in machinery the cost of manufacture of batteries will be considerably reduced, which will cause accumulators to be used by more of the small country plants where but little capital is invested in the business. It is probable that some of the improvements will take the form of a modified electrolyte which will be of such a nature as to prevent the formation of, or at once break up any deleterious substances which will be formed during charge or discharge.

It is also probable that batteries will be so constructed that the diffusivity of the acid will be greatly inreased.

This would prevent scaling, which occurs when the acid has become weakened or when a cell has been discharged below its minimum useful voltage.

It is very probable that the coming years will witness many of these improvements taking place.

Scientific Truths.

When an experimental fact was obtained by Faraday, it was instantly enlarged by his imagination—JOHN TYNDALL.

If we would judge fairly of the merits of a new invention we should not only look upon it by itself, but compare it with all that has gone before and might be superseded by it.—GISBERT KAPP.

Without the use of hypotheses or antecedent probabilities as a general rule, no extended series of investigations can be made as to the approximate cause of casual phenomena. They require to be used, however, with great care, lest they become false guides which lead to error rather than to truth.—JOSEPH HENRY.

What is the truth, is the goal of intellectual mankind in all ages, and its pursuit leads not only to intellectual but also to physical satisfaction.—PROF. HENRY A. ROWLAND.

Study science with earnestness—search into nature—elicit the truth—reason on it, and reject all which will not stand the closest investigation.—FARADAY.

The Automobile.

By HAROLD H. EAMES.

THE mechanical and scientific history of the automobile has been so constantly in print for the last four or five years that the public must by this time be thoroughly "saturated" with it. It is no longer a source of wonder or comment to the reading public that many great names connected with the development of prime movers, either academically or practically, have also been connected with the history of the automobile by indirect prophesy, if nothing else. That these great names include those of Roger Bacon, Sir Isaac Newton, Watt and others on a similar plane, is constantly being stated in the current print. The reading public ought to be now thoroughly familiar with the fact that Cugnot had an operative steam wagon about the middle of eighteenth century and to many of those who have little or no practical knowledge of the automobile, the name of W. H. James, Goldsworthy Gurney, Hancock, J. Scott Russell, and Trevithick are familiarly connected with the temporarily successful commercial operation of automobile passenger conveyances in the first half of the nineteenth century.*

The entire absence of such startling discoveries and inventions in advance of contemporary knowledge as have characterized many other arts has largely divested the history of the automobile of its interest to the public at large, and beyond the natural surprise occasioned upon noting the antiquity of the idea the history contains little of interest to any one not actually concerned in its development.

The regular mechanical evolution of the automobile, however, is now of secondary importance to the commercial. The major mechanical problems have either been already solved or the manner of their solution already determined and the result susceptible of accurate prediction. The opportune availability of already complete and experienced manufacturing organizations with not a little previous experience of the new industry made it possible by the expenditure of relatively vast sums of money to crowd into a few months a development which under generally similar mechanical and scientific conditions in the past has required years. As a result, the character of the "standard" or "type" of automobile from which the product of various manufacturers will depart, with relatively slight variations, is already recognizable, and to those well informed on the subject the "freak" is already easily distinguishable from the commercial type. Although the direct availability of the results of the previous developments of other industries has contributed immensely to the rapidity of development of the automobile, the extremely rapid development of the successful commercial type is nevertheless remarkable when compared with the mechanical development of ordnance material, bicycles, sewing machines and steam engines, or even electrical apparatus—although the last named hardly affords a perfectly fair comparison. Perhaps the most remarkable contrast is in the case of ordnance material—in the development of which the expenditure of money has been practically unstinted. It is only necessary to compare the numerous markedly differing varieties of alleged armor-piercing shell of fifty years ago, for instance, with what is practically the one type of to-day, to realize that the last eighteen or twenty months of automobile development represents almost as great a commercial advance.

In fact, the conditions are such as to make it seem entirely safe to assert that the present progress and probable future is much more likely to be determined by commercial considerations than any probable mechanical advance.

The automobile "industry" of this country may be said to be just crystallizing into a "business." Although the sales of automobiles have not been without profit to those engaged in it, such profit must be greatly diminished when experimental expenses now legitimately appearing as investment are written off, and the commercial work of the American automobile industry up to the present time must be regarded as almost entirely "missionary work" undertaken not only with a view to revealing the character and purpose of the automobile, but also to the tempering of the exaggerated views of the public as to the scope of their application to purposes of business and pleasure. In fact, one of the greatest difficulties encountered heretofore in the sale of automobiles lay in the specifications resulting from exaggerated ideas of prospective customers not only as to what was to be expected of an automobile, but even more as to the character of the services which they themselves desired to have performed. Few of those even using carriages in a business way had given any consideration to the capacity of the horse in terms of miles and it was not uncommon three years, or even a year and a half ago, for an ordinary city or suburban customer who made no excessive demands upon his horse equipment, to declare an automobile "unfit for his purpose unless he could be sure of 50 miles on one charge," at a speed far in excess of any which city and suburban roads and traffic conditions would have permitted him to use. The introduction of the automobile was also impeded by the confusion of mind resulting from the general similarity between the automobile and fine horse carriage, without which it was impossible even to claim the attention of that class among whom purchasers were possible in the earliest stages. The price of the automobile even this class of customer considered excessive, since it was invariably compared with the price of the fine horse-drawn carriage approaching most nearly to it in appearance, without regard to the added value returned for the price of the motive power. On the other hand, those who appeared to appreciate the value of the motive power were as a rule unacquainted with the usual price of fine horse-drawn carriages and made their comparison between the cost of motive power of more or less novel and special character, with the cost of the "standard" street car motive power of the present date.

Still another class, in some way for which I have not heard a satisfactory explanation, placed the automobile industry on the same commercial plane as the bicycle industry, and failing to realize the limitations as well as the possibilities of the automobile, demanded the qualities of a Persian wishing carpet for the price of a tandem bicycle. For these and analogous reasons the automobile maker has been compelled to appeal almost exclusively to that class of purchasers who, however unappreciative they may have been of the value of the mechanical features, were thoroughly familiar with high-class, horse-drawn vehicle equipments of all kinds, and in order to do this he was compelled to still further enhance the cost of the vehicle produced by employing in its upholstery and finish the most expensive material and workmanship, while the same necessity compelled him to somewhat hamper the mechanical simplicity of his designs by a strict adherence to the latest fashions in "carriage lines" and finish.

Once sold, he had a much more substantial but perhaps no more commercially serious difficulty to contend with than those just enumerated, namely, the almost universal ignorance of the practical care, limitations and strength and weakness of the storage battery. This difficulty was still further enhanced by the unchecked eruption of opinions from a large class of engineers familiar with the principles of the storage battery, but wholly ignorant of it "manually," and grossly unconscious of the entirely empirical character of the data which really affects the use and durability of the storage battery in practical service. Almost every purchaser had some engineer acquaintance who was regarded by him as his sole prophet, and, while in many instances the prophet was a thoroughly well-informed engineer, I can hardly think of a case in which, whatever may have been his general knowledge of the subject, he had had any experience in the use and care of storage batteries. The very eminence of many of these engineers made it diffcult to offer them instruction and the results were disastrous to the customers' impression of the durability of automobile storage batteries. In the very early stages this difficulty was further accentuated by the analogy which everybody attempted to draw between the requirements and performance of the stationary storage battery and those that were to be expected of the automobile battery. So persistent was the adherence to this analogy that great sacrifices were made in the pound-capacity of vehicle storage batteries in order to provide insurance against difficulties frequently experienced with storage batteries in other service but which experience has shown to be either wholly absent or commercially utterly insignificant in the automobile. The consequent decrease in mileage capacity still further accentuated the commercial difficulties resulting from the disparity between actual practical possibilities and the customer's exaggerated notions of his requirements. Furthermore, something of "a jump in the dark" resulted in the adoption by many automobile makers of types of batteries which, however well suited they may have been for any other purpose, were utterly unfitted for automobile conditions, and still further confusion was added by an attempt to draw conclusions from the performance of storage batteries on tram lines here and in Germany without rec-

*Gardiner D. Hiscock's work on automobiles provides perhaps as excellent a brief and comprehensive historical review of the art as is available to the ordinarily busy man, and I am indebted to it for the refreshment of my memory necessary to these remarks.

ognizing the immense difference in conditions imposed by the far greater weight limitations demanded in the design of the automobile. A glance at the various difficulties arising above will indicate, what proved to be the fact, that they acted and reacted in accentuation of each other.

The mechanical difficulties were relatively trifling. Where the customer's actual ownership of the vehicle or some other equally strong interest resulted in intelligent and proper care, assistance from the factory was seldom called for after the first month of service. The only serious mechanical difficulties occurred to vehicles in the hands of those much-to-be-avoided customers whose interests were in one way or another so allied with those of the automobile seller as to give him recourse to the manufacturer for assistance or to compel the latter from motives of policy to reimburse him for the losses resulting from neglect and a not altogether unnatural ignorance of a new art. Such customers necessarily lacked the incentive to foresee and prevent even those common difficulties which are almost inseparable from the operation of any traction apparatus. When added to this the partially allied customer was, or believed himself to be, an engineer, much unnecessary trouble and expense and retardation of progress of the industry resulted from the frantic attempts on his part to repair the result of continual gross neglect by radical, and above all, "original" changes of design based on preconceived notions rather than upon any experience with or careful study of the automobile, or any knowldege of the general "harmony" of the design and construction of the particular vehicle then under his notice. A careful comparison of notes with a considerable number of what may be called "prominent" automobile builders in this country indicates that these difficulties were practically in direct proportion to the intimacy of the interest between the maker and the customer. Barring those many cases in which the unfortunate investor capitalized originality rather than commercial utility, it is not surprising that the mechanical difficulties should not have been serious; for, most of the problems the results of which combine to make up the mechanical portion of the electric automobile had already been solved; although, in but few instances, except as inherited from the tram car, were any established general laws available. As a consequence and in illustration of this last-named condition it is interesting to note that the designs of early automobiles were much farther away from those of the horse-drawn vehicles than those of to-day. In other words, as in the parallel case of the metallurgist and blacksmith, the laws being established by careful experiment on the part of the automobile engineer, are continually found to be justifying the results of the horse carriage maker's inherited experience of centuries.

In overcoming the above difficulties it was some time before Americans came to realize how little the commercial portion of the American automobile trade was to be judged from or likely to be assisted by a knowledge of the commercial conditions prevailing in France, and some good time was lost and not a few blunders appear to have resulted therefrom. But, singularly enough, perhaps the only commercial feature of the French trade universally applicable to the early stages of the business was wholly and persistently ignored by American beginners, many of whom seemed to think no returns worth while unless expressed in six figures and to whom it seems rarely to have occurred that the great expense necessarily inseparable from the rapid establishment of a wholly new business justified a consideration of the question of "minimizing losses." This feature is the result of French thrift and is exemplified in those successful Paris firms by whom automobile sales, boarding, livery, repair and sundry business are combined. That the American automobile maker should have instinctively turned toward the French for data is natural. Active automobile experimenting can hardly be said to have begun in this country until the spring of '95, but the automobile had been continually gaining ground in Europe since the middle 80's, although not until '93 or '94 did it command public interest to any considerable extent. Unfortunately for the analogy, in France the automobile was essentially a fad and seems still to be so in the main. In this country, from the beginning the possibility of *permanent* success seems to have been regarded as lying in the direction of business vehicles of one kind or another, although the realization of this expectation has been long delayed by the relatively high first cost of business automobiles when compared with horse-drawn vehicles and the relatively high up-keep, almost invariably traceable to the ignorance and neglect of the user and in a less degree to the conditions inseparable from the development stages of design.

Within the last few months, however, the four or five years of untiring missionary and educational work, the splendid organizing work and business capability recently shown by a company conducting a livery service in our largest city, the tremendous strides made in the adaptation of the storage battery to vehicle service, and above all the real practical advantages of the automobile itself, are beginning to reap their reward. The inquiries from customers wishing automobiles for business purposes are no longer adroitly worded inquiries for "something" to do service heretofore most unsatisfactorily performed by the horse or to which the horse is utterly unadapted—nor is the advertising value of the automobile as a novelty apparently any longer the incentive for their employment except on the part of the back-woods customer who is totally unable to buy one, anyway.

Nor does the customer who wishes to purchase an automobile for pleasure purposes any longer investigate it with a view to its substitution for the suburban local railway train or trolley service.

The bona fide inquirer for business wagons has been studying the subject now for over three years to my certain knowledge and is beginning to find that strict ledger comparison of horse and automobile service is beginning to be strongly in favor of the latter, and the purchaser of pleasure carriages has learned how far he usually wishes to go with a horse and how fast he usually goes, and where it is merely a question of transportation, without reference to the horse as a means of sport, he is beginning to be convinced that the automobile affords him every advantage.

Of course, as implied above, the great improvement in the vehicle storage battery and the still greater improvement in the dissemination of the knowledge of the care of it, play a large part in the change of attitude of the buying public. The mileage of the average automobile equipped with the most durable American storage battery is to-day fully 50 per cent greater than it could have been with the same general type of storage battery of four years ago. Even with the violent, and, from the French point of view, ruinous methods of vehicle battery charging employed here, this type of battery in delivery wagon service with otherwise proper care can be counted upon for 6000 or 7000 miles of reliable service. In France, with careful all-night methods of charging, 100 discharges of 60 kilometers each are habitually expected from what we Americans regard as the most inferior and flimsy type of pasted battery. Under some further limitations the French automobilist expects and is reliably said to obtain 200 60-kilometer discharges from this same battery. The combination of French methods of charging with the most durable type of storage battery certainly suggests an enticing combination and an expectation partially justified by the remarkable durability records of similar batteries in tramway service. The brief and general figures just given cannot but serve to emphasize the thoroughly conservative nature of the figures given by Mr. Fliess in the excellent articles published in the ELECTRIÇAL WORLD AND ENGINEER of Oct. 6, 13, 20 and 27, in which the observation of actual practice on a considerable scale justifies me in saying the author still more conservatively underestimates the advantage to be gained by operating a considerable number of similar vehicles at the same time and place as well as the advantage in investment and up-keep resulting from the added ground covered per vehicle in such a station. In short, it is only within the last few months that the public has been educated to a point to consider the automobile in competition with or as a substitute for horse service, and while this is mainly the result of a gradual development in the public mind, it is to a minor degree the result of the improvement in the vehicles themselves, especially the storage battery, and in a somewhat greater degree to improvement in the knowledge of the care thereof. This gradual change to a substantial and practical attitude certainly justifies the declaration that the automobile has come to stay.

The above paper has been substantially confined to a consideration of the past and possible immediate future of the business in automobiles applied to purposes of trade and convenience, because of the writer's conviction, shared in common with many others connected with the trade, that in these directions must we look for the permanent business sufficient to justify any considerable permanent investment. That there will be, and in fact already is, a considerable business in automobiles for purely pleasure and sport, is undoubtedly true, but I believe past industrial history justifies the belief that this portion of the business will be subject to the same vicissitudes that have applied to the history of almost all trades in pleasure and sporting articles and may be expected to be transitory or at least intermittent.

It seems reasonable, however, to expect a somewhat more nearly permanent and substantial trade in that other line of carriages now most prevalent in France which combines with sport and pleasure the convenient accessibility of country clubs and neighboring

towns and the gratification of the growing American desire for touring initiated by the bicycle.

That electricity will be conveniently adapted to this subdivision of the trade seems not likely to take place for some time to come. Whether it ever will be must depend largely upon the progress in the development of other forms of motive power in the meantime. Whether, on the other hand, a remarkable advance or discovery in these other forms of motive power will result in serious encroachment upon the field of the electric vehicle, in its application to business and convenience, as discussed in the above paper, depends upon the advance in the storage battery in the meantime, and, above all, upon its reduction in cost. The necessity for great improvement in its durability, while most important, will no doubt be largely mitigated by the improvement in the knowledge of its care.

That at present some other motive power than the storage battery will be found desirable in the heaviest business traffic, seems probable, but for light and moderate weight-carrying service and general convenience the storage battery bids fair to continue to be the most suitable of all.

The limits and somewhat hasty preparation of the above article have compelled me to confine myself to the consideration of those past and present commercial difficulties more or less peculiar to the automobile business, and which, added to a knowledge of the facts and conditions almost invariably inseparable from any new business, will be of assistance in forming a prediction as to the prospects of the immediate future of this particular business.

Neither time nor space permits a discussion of the special application of those early diseases common to almost any industry of this general commercial kind. I have consequently referred only indirectly to the difficulties arising from the adoption of measures for stock market considerations rather than from those of business expediency the application of the sales methods of the wheat pit in place of the principles which should govern the sales of merchandise; the embarkation of capital into the business with little or no consideration of the commercial conditions or any attempt to obtain data thereon; the investment in manufacturing a single variety of vehicle selected upon a pure guess as to what the future demand would be; the wasteful investments which have resulted, on the other hand, in manufacturing the greatest variety as a very proper means of disposing of the entire business at an opportune moment; the errors, both mechanical and commercial, resulting from an attempt to follow the ideas of the dataless and self-announced exemplar of the public demand; the mechanical criticisms of influential people with no better special mental equipment than a large vocabulary of mechanical terms and an unbounded confidence in the accuracy of their inner consciousness.

All these difficulties have been practically common to almost any rapidly developing industry, and a discussion of them has been purposely omitted to give way to the discussion of a few of those diseases which have been most prominent in this particular case.

The Tercentenary of Electricity.

At the London Institution on Dec. 17, Prof. Silvanus P. Thompson gave a lecture on the "Tercentenary of the Science of Electricity." This tercentenary, he said, was to be dated from 1600, because in that year appeared Gilbert's treatise "De Magnete," in which it was shown that the attraction of the loadstone for iron was not the same as that exerted by amber for small particles of chaff, feathers, etc., and that this property of amber was shared by many other substances. In the century 1601-1700 Guericke constructed the first electrical machine, using a ball of sulphur, but very little more was discovered. In the next ceutnry there was a galaxy of names illustrious as contributors to the progress of the science of electricity. Still the real beginning of its useful applications dated only from the earliest part of the nineteenth century. Volta, in 1800, gave an account of the voltaic cell, and in 1802 Sir Humphry Davy, experimenting at the Royal Institution with a large battery of cells, produced the electric arc for the first time. About 1836 Daniell constructed a cell whose current was constant, though not very strong, and a few years later Grove invented his more powerful zinc-platinum cell, showing in 1841, in the theatre of the London Institution, that a battery of 100 of these cells could yield an electric arc 4 ins. long.

Future Development of Interior Wiring.

By H. WARD LEONARD.

THE wiring of interiors of buildings is a subject with which almost every one living in towns and cities is likely to have some contact, and hence it may be interesting at the beginning of a new century to speculate a little upon the probable development interior wiring will see in the future. Since the future can only be judged by the past, and the past of this subject is represented by only about eighteen years, it is perhaps rather rash to attempt to say anything very definite. However, although we have only eighteen years of development to judge by, those years have seen such an enormous amount of interior wiring done in every civilized country and under so many different influences that certain conclusions may perhaps be fairly drawn as to what is likely to be the trend of the future development in this class of work.

There can be no doubt that the most important matter to be kept in mind when considering the subject of interior wiring is the fire risk. This is especially true in this country where wood enters so much more into the construction of ordinary buildings than it does in European countries.

Probably most of the interior wiring at present in use in this country can fairly be said to be a poor fire risk. This is because most of it was done under the mistaken notion that fires from electric wires were generally caused by overheating of the wires, due to their being too small for the current carried by them, or else that the fires were due to short circuit between the wires.

As a matter of fact there have been very few fires which were due to the use of wires of too small size for the current employed. The fires caused by short circuits have also been but a small percentage of the whole.

The high resistance leak between the two wires is the great cause of electric fires.

Such a leakage current, which may be a very small fraction of an ampere, has no appreciable effect in heating the wire and does not cause any fuse to blow. It is most difficult to test for, as it does not necessarily mean a ground connection. Such a high resistance leak may measure several megohms some days and in a few days it may measure only 1000 or 2000 ohms, if there is some atmospheric or other cause of a slight dampness on the materials between the wires. This condition of affairs causes an electrolytic action which in the course of months or years will reduce the size of the wire at the leakage place to such a small diameter that finally the normal current will cause the wire to melt at such a point. Then an arc, of perhaps 4 or 5 amperes, supplied by perhaps 100 volts, develops, and here we have the best possible condition for a fire. After the fire has burned a short time the resistance between the wires of opposite polarity becomes so low that the increased current blows a fuse. The short circuit and the fire ordinarily disguise the original cause of the fire and it is reported as a fire "due to wires becoming crossed" or "overheated by the current."

It will be evident that the small wires of the distributing circuits are the ones most likely to cause fires from such a cause. Very few fires are caused by the feed wires or the mains between the feed wires and the distributing circuits.

To avoid such fire risks, both poles of the circuit should be enclosed in the same metal conduit and that conduit should be thoroughly grounded. Under these conditions the dangerous high resistance leak working for months or years becomes impossible. If a leak occurs, it develops rapidly into a cross, blowing the fuse promptly; and if the metal conduit is grounded throughout its length no difference of potential between different portions of the conduit system due to contact with the wires inside of them can exist except momentarily, since this would be practically a metallic short circuit and would instantly blow a fuse.

Very early in the history of interior wiring the writer advocated strongly the method of wiring described, but the underwriters and fire departments of the early days believed in paper conduits, a large distance between wires of opposite polarity, and only one wire in a conduit; and such a radical departure as putting both poles in plain iron pipe and grounding that pipe was not permitted, but after many years and a few unimportant installations, the writer finally, in 1892, installed the first wiring system of this kind. It consisted of several

thousand lights in the Cable Building in New York City. Two first-class rubber-covered wires were used in an ordinary gas pipe; special elbows, tees and similar devices being employed at the joints and bends. This method of wiring has since become very general and to-day the importance of having both poles in the same metal conduit is well appreciated in the principal electrical centres. But within a few miles of New York City, so called electrical experts still continue to install wires on porcelain insulators, separated by a few inches only, and placed between the floors and in the walls of frame buildings. It is to be hoped that the ignorant helper who puts the wires in place will not let the wires touch the wood or plaster or metal work anywhere and that no moisture due to a leaky roof or water pipe will ever cause a high resistance leak. It is also to be hoped that the insulation on the wires will be unaffected by years. But the chances of trouble in the future from such wiring are extremely good and the underwriters are of late quite properly concerned at the growing increase in fires due to electric wires several years after the installation.

Next to safety, as regards fire risk, the most important requirements in considering interior wiring is that the wires can be readily pulled out and renewed in case of any desirability or necessity. This again leads to the use of a substantial, amply large conduit, and there is nothing better than a good-sized iron pipe.

The voltage and character of current may change so that the wires installed in the past may not be the best for the supply system of the future; but if we have good permanent iron-clad holes of ample size ready at all times to receive the new wires desirable, we are safe, and also able to take advantage at slight expense of all probable developments in interior wiring, but it must be understood that unless a conduit is large enough to permit of the wires being pulled in and out after the building is finished and occupied, it is useless as a conduit.

It seems to be safe to predict that metal conduits will be practically universal in the installation of interior wiring in the future where the building is of the usual character in this country. In most European countries the use of plaster, stone and tile for floors and roofs, and generally where we employ wood, makes the risk of fire from electric wires extremely slight in comparison with the risk in this country. I think it can be stated, without fear of contradiction, that the habitual grade of wiring in European countries to-day is worse than we have had in this country for fifteen years. Any kind of wiring is safe as regards fire risk in a building which cannot be burned. This is probably the explanation of the poor grade of wiring so commonly met with in Europe.

In the future development of interior wiring, one of the most important factors will be the very great convenience and economy which can be obtained from a properly designed wiring system, as compared with any conceivable development in the use of gas or other known illuminants.

The average dwelling of to-day is wired so that electric lights are placed and used almost as gas lights are placed and used. There is no greater mistake than this. The electric distribution is flexibility itself when compared with gas distribution and the chief advantages of electric lighting over gas, lie in the possibilities of placing lamps anywhere we want them and controlling them by switches placed just where they will be most convenient to use.

There is still great room for improvement in the careful arrangement of lights and of the switches to control them. Usually the owner of a residence tries to see how few lights he can get along with and contents himself with a very few switches. In doing so he not only loses the chief advantage possessed by electric lighting over other forms, but he also greatly increases the cost of using it, for the easiest and surest way to economize in the use of electric current is to have plenty of switches, so that any desired lamps can be operated, without operating those not wanted, and to have those switches placed so conveniently that it is really no effort to switch off the lamps, as soon as they are not required.

As to safety devices, it has been already pointed out that there is no way at present known of protecting wiring poorly installed. The safety fuse has seen a great development in recent years and is likely to be used indefinitely, as it is a simple and sure means of opening the circuit in case of excessive current. But it is not a convenient device, since the ordinary user of electric lights is obliged to send to the electric supply company to replace a burned-out fuse.

There is a strong demand for a small, cheap, reliable automatic circuit breaker, but thus far the size and cost of such devices have prevented their introduction for the ordinary circuits of interior wiring. What is needed is a small automatic circuit breaker which will be a substitute for both the present switch and the fuse. Such a device has already been produced, but it is impossible to make it compete in first cost with the ordinary switch and fuse, and it will take time to make users pay the additional cost for automatic circuit breakers, just as it took time to make them pay for the present expensive conduit systems.

Fuses will always have a field and in many instances will be installed in addition to such automatic circuit breakers if they should come into general use, but the fuse should be so large that it will not burn out, except upon failure of the automatic switch to act.

In many respects the interior wiring of to-day is very perfect and in most points it has been rapidly evolved to a state of final permanence, which is without parallel, when we compare its development with the development of systems for the distribution of water, gas, steam, etc., in the interior of buildings.

The greatest bar to the general introduction of really first-class interior wiring is the prevailing notion that since "electricity is in its infancy" and since "no one knows what it really is," that therefore no consulting engineer is of any use and that the local bell hanger and "electrician" is just as good to design and install the wiring system as the large, experienced, electrical engineering and contracting concerns.

An interior wiring system designed for the ordinary residence or other building by a small concern having no engineering staff, and especially when it is designed to suit the owners' desire to "make it as cheap as consistent with first-class work" is probably as great a waste of money as can be found in a modern building. For a few months or years the owner rests contented under the mistaken impression that the underwriters' certificate means that he has a thoroughly first-class wiring job, and in some instances he never learns how far this is from the truth. But if he ever has to investigate the matter because of fire, or any modifications, or repairs, he usually finds that he will have to spend several times as much to make his wiring safe and convenient as it would have cost him had he dealt with the most responsible and highest-priced concern in the beginning.

When all interior wiring jobs, no matter how large or how small, are done under the specifications and supervision of competent and experienced electrical engineers, or are done by contracting concerns, having first-class, high-salaried electrical engineers on its staff, we shall see a striking development in the interior wiring in general use and we shall also see the last of the electrical fire risk; and repairs due to defects will be as infrequent as in the case of modern gas pipes.

There is every reason to feel confident that the present comparatively low efficiency of the incandescent lamps will yield to the continued pressure of inventive genius, and it seems safe to predict the commercial use of a lamp of 1 watt per candle within our lifetime. There is, however, no reason to expect that improvements in this direction will have any radical influence in changing the methods of interior wiring.

The future development of interior wiring as viewed by the writer may therefore be summarized as follows:

1. All concealed wires will be placed in iron conduits, both poles of the same circuit being in the same conduit.

2. Distributing centres will be located at convenient places, and iron boxes placed there to contain automatic circuit breakers and fuses for connecting the mains with the distributing circuits.

3. The lights will be located in the most advantageous positions to secure specific results in lighting rather than the general illuminating now secured by large groups of lamps. In order to secure the best lighting effects, the lamps themselves will not be visible, except at a distance.

4. The arrangement of circuits and the location of an abundance of switches will be carefully studied so that the greatest convenience and economy will be obtained. The switches will be small automatic circuit breakers placed in iron boxes, flush with the surface of the wall, and frequently the automatic circuit breaker will have in combination with it a small dimmer, so that the candle-power of the lamps can be controlled at will.

Opinions as to Science.

The great majority, even of the students of science, must take their opinions ready-made as to science in general; each knowing, so far as he can be said to know anything at first hand, only that little corner which research has made especially his own.—S. P. LANGLEY.

The Telegraph.

BY PATRICK B. DELANY.

ALTHOUGH the electric telegraph had been hinted at a century or more before, it may be said that Morse, of America, and Steinheil, of Bavaria, began almost simultaneously to make a practical method. Morse in 1837 made his first demonstration at the University of New York over a third of a mile of wire strung around a room, and a year later, with the help of the superior science of Joseph Henry and the mechanical skill of Alfred Vail, ten words per minute were transmitted over ten miles of wire at the same place. Henry, it must be remembered, rang an electric bell through a mile of insulated copper wire, similarly strung, seven years before. Morse began with what might be termed a short line recorder, using combinations of dots requiring a code book for preparing and transcribing messages. Henry had invented the long line instrument, Vail conceived the embossing register and, with or without Morse's help, supplied what is known to-day as the Morse code of dots and dashes.

Upon this foundation the system grew, until six years later, when the first practical telegraph in this country was put in operation between Baltimore and Washington.

The apparatus was crude and clumsy, but all the elements essential to success were there. In fact, about all that has been done to the Morse apparatus since has been by way of refinement and cheapening. The sounder has taken the place of the recording instrument and the trained ear and nimble fingers of the operator have raised the *possible* speed from ten to fifty words per minute, the average being below twenty, however.

After the Morse came the House printing instrument, which, considering the time, was by far the most ingenious combination of electro-magnetic-mechanical effects ever produced, and compared with which the work of others appears very simple.

After this instrument had been perfected and put into successful operation the inventor went back to his farm in Vermont, and after twenty years or more emerged from his seclusion with a wonderful conception which he had thought out in the furrow as he followed his plow, and worked into shape when the candle was low. He brought this machine to Brooklyn seventeen or eighteen years ago and showed it in experimental operation. The patents covering it have been "bunkers" in the game of telegraph invention ever since, affording at the same time a convenient "reference" for the Examiner at Washington for suppression of over enthusiastic inventors in this field. It is easier for the inventor to contrive a new departure than to argue House's "references" with the Examiner, neither of them having any clear understanding of its operation.

House's new machine was designed to operate on a selective plan and drop off printed messages at any station desired at a speed of about sixty words per minute, and to lock stations in and out of the line obediently to the operator's will. He invited his old contemporary, D. H. Craig, to witness the operation of his machine.

Craig saw it, and then took House over to the American Rapid Company's office, in New York, and showed him how messages were being sent between New York and Boston at several hundred words per minute. The old inventor soon after packed up his symposium of intricacies and went back to his farm. He died at Bridgeport five or six years ago, having worked half a life time with marvelous genius, apparently oblivious to the strides of improvement abroad in the land.

Just as House's original printing system went out of use Hughes brought out his printing telegraph, in a measure a modification of House's machine, and this was followed later on by Phelps' combination of the two, but the more simple and comparatively inexpensive Morse system usurped the field in this country.

In Europe, on the Continent especially, the Hughes printer has been extensively used for about thirty years and brought fame, fortune and honors to its inventor, whose most noteworthy achievement besides, was the discovery of the microphone.

In England Cook and Wheatstone were pioneers in practical telegraphs. The A B C dial instrument, the single and double needle, and the fittest survival of the lot, the Wheatstone automatic system, which to-day is carrying all the press matter and a good portion of the regular traffic for the British post office, are good testimony of the genius and industry of these co-workers.

About 1868 J. B. Stearns, of Massachusetts, duplexed the Morse system, making one wire about equal to two in carrying capacity. A year or two later Edison invented the quadruplex, and had this been the only achievement of his fertile brain it should entitle him to everlasting distinction. This quadruplex system is used most extensively in this country and England. According to a statement made several years ago by the late Norvin Green, at the time President of the Western Union Telegraph Company, the artificial or "phantom" circuits, created by the quadruplex, represented in value over ten million dollars to that company alone.

In 1884 the Delany synchronous multiplex system was perfected. It has not been used in this country, but was adopted by the British post office in 1885 and has been extensively used on all the leading routes in that country up to the present time. By it six Morse circuits are obtained over a single wire and all may be worked in one direction, if required, the circuits, unlike the quadruplex, which permits but two transmissions in one direction, being as independent of each other as though six wires were used.

The Morse, Wheatstone, and Hughes may be said to do the world's telegraphy at present. Each has been improved from time to time, both as to speed and distance of working, and the improvement in lines has contributed largely to their increased efficiency as well.

All these systems are based upon electro-magnetic effects. Without the electro-magnet not a single dot could be sent over land or sea nor a single word spoken by telephone. Even the wireless system of Marconi is dependent on Oersted's discovery. It disclosed the foundation for all electrical development, of which the telegraph was the forerunner.

Until Steinheil discovered that the earth would answer for the return half of the circuit he and Morse used two wires—one for sending, the other for receiving messages. Steinheil, in trying to utilize the two rails of a railway, found his transmitter short-circuited, and when one of Morse's wires, between Washington and Baltimore, broke down, he found that work went on just the same.

Up to 1876, when Bell exhibited his telephone at the Centennial Exhibition, no one dreamed that the telegraph would ever have a competitor in the field of electrical communication. Indeed, for several years after the telephone became a far speaker it was snubbed and scorned by the telegraph magnates. It was offered to them, lock-stock-and-barrel, for less than the price of a good race horse, but overconfidence begotten of monopoly, and prejudice allied to short vision, forced it to set up for itself. Its growth is known to everybody.

This invention by Bell and the wireless system of Marconi stand as the two great departures in electrical communication since Miss Ellsworth's message "What God hath wrought." Like Morse, Bell and Marconi have had their forecasters—purveyors to the architects, as it were.

The state of the art of electrical communication to-day may be summed up as follows:

Telephony	60 words per minute
Single Morse Circuits	15 words per minute
Duplex Morse Circuits	30 words per minute
Quadruplex Morse Circuits	50 words per minute
Multiplex (six circuit)	80 words per minute
Wheatstone Automatic	125 words per minute
Wheatstone Automatic Duplex	200 words per minute
Wireless	10 words per minute

These facilities, keeping in mind the restrictive charges, are ample for the amount of traffic offered. Increase of business can only be handled by increase in the number of wires, but this condition and its continuance falls far short of the legitimate demands of the present, and offer no relief for the future.

The present systems will not admit of any material reduction of rates. The average 30-cent 10-word telegram, and the dollar per hundred miles five-minutes talk by telephone, under most careful management and present capitalization, will not yield over 5 or 6 per cent dividends. Thus far the telephone has derived its great profits from local exchanges and rental of long circuits for private use. The private line business of the telegraph companies is to them the most profitable also. Combined, the telegraph and long-distance telephones do only about 5 per cent of the correspondence numerically, and probably not more than 2 per cent in volume, and their total yearly earnings (exclusive of local exchange business) is less than one-half the amount realized by the post office from the sale of stamps for first-class matter.

Letters average about 30 for each inhabitant. Postal cards 7. Telegrams 1½.

Undoubtedly before the new century is ten years old, at least one-half of the correspondence, now carried by train, will be telegraphed, at an average rate for the whole country of 15 cents for 50 words, or five times as many words for one-half the present telegraph toll.

It is practicable to begin this change at once, but not by present methods of operation. It is only possible by the chemical automatic system.

In 1846 Alexander Bain, of Edinburgh, conceived the idea of punching telegraphic characters in a paper tape, and then transmitting them by passing the tape through a machine which automatically made contacts through the holes. The message was received on a paper tape moistened with chemicals. An iron pen connected to the line resting upon the top of the tape passed the arriving signals through the paper to a drum over which it was drawn continuously, the drum being connected to earth, so that the pen, paper and drum formed part of the circuit. The discovery of the electrolytic action involved in this operation is said to have been made by Dr. J. Redmond Cox, of Philadelphia, in 1810, and afterwards amplified by Davy and others. This idea of stencilling messages on tapes laid the foundation for the present Wheatstone automatic system.

Bain's system was defective in all its main features. The perforator was crude, and his transmitter and all those used in subsequent attempts could not be relied upon to make contacts through the holes in the tape. The records on the receiving ribbon for high speeds on short lines, or moderate speeds on long lines were, owing to retardation, run together, so that translation was difficult and liable to error. These drawbacks have all been overcome, one by one, until recent demonstrations by the writer before scientific bodies, over artificial lines and over regular lines in actual practice, have shown that 4000 words per minute can be plainly recorded from New York to Philadelphia, 1000 words per minute New York to Chicago, and 200 words per minute New York to San Francisco direct, without repeaters, over a single wire. As an evidence that the speed of this system is only limited by the line, and is in no way restricted by the apparatus, 8000 words per minute have been plainly recorded over an artificial circuit of 250 ohms, 2 microfarads capacity, with 110 volts. This, with proper computation of letters and signals involved, amounts to over 2500 impulses per second plainly recorded, the sending tape passing through the machine at the rate of 8 ft. per second.

With such a system all the mails between any two points in the country can be telegraphed over one or two wires.

The train time will ere long be eliminated from correspondence and the Post Office will be used for collecting and delivering these "electropost" communications.

Postal telegraphy by the Government may, owing to political prejudices, be delayed, but utilization of the postal facilities locally in co-operation with private enterprise for long-distance transmission, will accomplish about the same results. Nor is any special legislation thought to be necessary to bring this about. The Postmaster General, having authority to contract with railways, steamships, tube companies and others for transportation facilities, surely has the power to contract with a telegraph company to deliver to the Post Office at one point preferred letters or "electropost" communications handed to the company at another point, enveloped, addressed and duly stamped, at a fixed price, and within stipulated limit of time. In this way a letter filed with the company at Chicago would be in the carriers' pouch in New York in less time than it would take to transport it from the Chicago Post Office to the train.

Liberal subsidy for the saving of time in mail carrying has been the policy of the Government from the beginning, as shown by the evolution from postboy and packet boat to the cannon-ball express and oceay greyhounds. An hour's reduction in the time of a thousand-mile run on land or an ocean trip commands the preference of the mails by the company achieving it, and, both locally and lengthwise, no expense is spared to expedite letter conveyance. A 10-cent stamp is used to hurry delivery so as to gain perhaps half an hour; sub-offices convenient for distribution are established without regard to expense, incoming steamers are boarded down the bay by sorters, and an army of mail distributing clerks are constantly on the go all over the country for the purpose of saving a little time.

Private enterprise will soon appreciate that this mine of business, amounting to about $75,000,000 annually, is worth competing for, setting the advantage of practically all time saved against the difference in expense. When the public realizes that the Post Offices throughout the country are but half an hour apart, and that replies to letters may be received in the same day for a charge not much more than the extra delivery stamp each way, it will be more than strange if letter transport by train, for business purposes at least, does not stop altogether.

A few substantially constructed wires over leading routes, taking in all cities of 25,000 inhabitants and over, leaving to the present methods the broker and exchange business, but using the Post Office, its trolleys, tubes, automobiles and bagmen to collect and deliver telegraph letters, will work an amazing change in correspondence in a short time. The Post Office cannot complain so long as it gets its postage at each end and without the expense of intermediate transportation.

This revolution cannot come by any electro-magnetic system. The Morse will continue to hold its place for speculative exchange business and train dispatching, but the great bulk of ordinary business will be carried by the system admitting of increase in volume and decrease in cost. Further improvements in electro-magnetic telegraphy need not be looked for. The limit in multiple and "phantom" circuits over a single wire has been reached. In fact, deterioration may be looked for, owing to the spread of trolley and power currents through the earth. In many notable instances already quadruplex workings have been seriously impaired, it being next to impossible to maintain a balance against a change of potential varying from zero to 60 volts, which is not infrequent between working points. It is useless to talk of increasing speeds by more sensitive apparatus, as has been proposed; the present instruments are much too susceptible to the stray currents which find their way into lines at every ground connection. Present indications are that ere long all balanced systems of telegraphy must be provided with metallic circuits or given up.

The chemical automatic system employs no electro-magnets, has ample margin for recording over and above all variations from extraneous causes, and is only limited in speed to the carrying rate of the wire itself.

The telephone is surely destined for the greatest domesticity, locally. It will be "a household word," but for long distance it must always be an emergency means, on account of the cost. Sixty words per minute (a fair average) or 30 words for each wire, will not admit of much cheapening. The time is coming, however, when the telephone and the machine telegraph will be associated in a way that will appeal to every telephone subscriber extensively engaged in business. Leading concerns will have a machine telegraph set, which will enable them to shoot into a correspondent's office, similarly equipped, 1000 words or more in a minute, to be transcribed at leisure by the typewriter, the message or letters having been prepared by the sender's typewriter, so that any business concern or newspaper may have private electrical mail facilities as many times a day as they wish to call up, and have ample opportunity for conversation within the telephone time limit as well.

These advances in cheap and general telegraphy, together with the spread of the uses of the wireless system in its legitimate field, where wires are impracticable, will all come about while the century is still young. The evidences being already here, prophecy has no place.

What the centenarian of a hundred years hence may see, a prophet should leave to his son to prophesy. In the way of telegraphy, doubtless the ships amain will hold converse with each other, and correct their chronometers with the last observation a hundred miles away. They will be in constant communication with the shore through the air or by wires on the bed of the ocean, but as the trip from the Hook to the Lizard will be done in a day, and probably without touching the water, only the over-anxious will want a dispatch. Communication with Mars has already been pre-empted, and *seeing* by electricity may be no longer visionary. Our five senses may, forsooth, all be "wired" wirelessly.

Military Engines of the Future.

General A. W. Greely, U. S. A., in the New York *World*, says, in regard to military engines of the future: "Scientific forecasts for a century must be regarded as merely vague suggestions, especially in an age of such tremendous advances as have characterized the nineteenth century. War in the twentieth century must, to a greater extent than ever before, make tributary the sciences of commerce and industry. The evolution of offensive military methods must invariably be in the direction of improved mechanism which will be automatically operated. Improved means of operation, communication and transportation will surely follow, as indispensable to efficiency."

One Hundred Years of Electrical Industry and Finance.

BY T. C. MARTIN.

WHILE it is true that the old century started its career with the noble gift from Volta of his battery, it cannot be asserted with any propriety that electrical industry then began. Doubtless, as in the time of Franklin or of Gilbert, somebody was paid for the manufacture of the philosophical apparatus used for experimentation; but only the lightning rod appears to have existed a hundred years ago as an article of commerce. The writer has seen professional bills for electro-medical treatment presented and paid while yet the nineteenth century was young, but he hesitates to regard that as being strictly industrial. It might be included under the head of finance. There are, however, no statistics available as to the annual production then of frictional machines and Leyden jars.

In the early thirties came the first indications of electrical development in this country, in the attempts to float Thomas Davenport's motor inventions and the assistance rendered to Morse by the Vails, the acquisition of an interest in the telegraph by Mr. F. O. J. Smith, and finally the period of industrial and financial exploitation through the formation of the Magnetic Telegraph Company in 1846, with a capital of $60,000, of which half went to the patentees, while for $15,000 cash the stock subscribers received the other $30,000. Even those who would deny to Morse the individual invention of the telegraph must admit some right on his part to the proud title of

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☞ Shares for sale by the Agent, EDWIN WILLIAMS, No. 76 Cedar-street, New-York. Present price of Shares Dollars, payable in cash.

EARLIEST KNOWN AMERICAN ELECTRICAL STOCK CERTIFICATE.

Father of Electrical Industry in America, and of an investment now representing over $3,000,000,000 in capital obligations. If these figures are doubled for all the rest of the world—a total to be taken with "E. & O. E." attached—the arts of electricity in seventy years have added $6,000,000,000 to human wealth. For the United States of America the half can be very easily established.

Telegraphy in this country has run up to a value of over $250,000,000, of which the Western Union and Postal Telegraph systems may be taken at not less than $150,000,000, the dividends on which have gone on steadily many years, the profits of the Western Union having grown from $2,227,965 in 1866 to three times as much thirty years later. Every railroad system has its telegraphs, on which immense sums have been spent. The New York Central lays out $300,000 a year on its telegraphs. There are in addition all the "district messenger" companies, all the police and telegraph systems, and some 800 cities with fire telegraphs. This does not include burglar alarms, thermostatic protection, etc., all of which are essentially telegraphic. Nor need the estimate include any large allowance for ocean cables, now rapidly approaching 200,000 miles, in which there is considerable American investment. In short, with the Western Union system alone standing for about $115,000,000, it will be seen that $250,000,000 for the total is rather low. It may be doubted whether the increase for land lines in the new century will be great, for the growth of the telegraph has been visibly checked by its offshoot, the telephone. But if the habit be formed of sending letters by telegraph, the figures will soon take a gigantic stride forward.

The value of the telephone business of the country, starting from Bell and Gray in 1877, may be put at around $400,000,000. The Bell system alone in 1898 stood for $160,000,000, and should to-day represent $200,000,000, with 2500 exchanges and offices, and 1,700,000,000 connections a year. The recent growth of the "independent" service has been enormous, and a complete list of its exchanges shows some 5000 names, with subscription lists as large in total as the Bell. Their capital investment and its return cannot yet be equal, but there must be at least 1,500,000 telephone subscribers, all told. If the average subscription throughout the country be put at $40 a year, the earnings are $45,000,000, and if the operating expenses are 50 per cent, the net is around $20,000,000, or 5 per cent on $400,000,000, as estimated. There would go into this amount a large expenditure for many years past on "interior" telephone systems, and by steam railroads, street railway, and other companies and persons, to which may now be added numerous hotels and apartment houses. As to the future for the telephone, it seems illimitable. There are some 15,000,000 families in this country. If business telephones be excluded, not half a million of the families have the benefit of the invention, but nearly all want it. A few people will be kept busy this century supplying them.

Electric lighting has been a favorite field for investment for twenty-five years, and the work of such men as Brush, Edison, Weston and Elihu Thomson now rounds up in this country a capitalization of at least $1,200,000,000 for central station companies, isolated plants, municipal plants and ship lighting, etc. There are between 2500 and 3000 companies, with obligations of about $750,000,000, of which a good half is bonded, and nearly the whole of which is in an excellent earning shape, its securities being strongly held. Isolated plants are believed to cover about half of the incandescent lighting done. It would appear that there are over 500,000 arc lamps doing duty, and the number of incandescent lamps connected is between 20,000,000 and 30,000,000, the latter number representing the annual American production, giving the lamp an average life of 600 hours, or two hours daily use, roughly, for a year. At only 1 cent one hour per day, 15,000,000 lamps are earning not less than $45,000,000 per year for the central stations; the arcs are earning $25,000,000, and the motors now connected probably more than $10,000,000. At between 50 and 60 per cent net, this would leave, say, $30,000,000 for charges and dividends, or not less than 4 per cent on the $750,000,000. In fact, central station earnings have been estimated at over $50,000,000 for the incandescents alone, but, as will be noted, a total much lower than that has been assumed. The figures for isolated and municipal plants might be put on an equivalent basis. There is no good reason to question the total for the lighting art at well over $1,000,000,000, and somewhere around $1,200,000,000.

The street railway industry nearly doubles that sum, big as it may appear, and is much more susceptible of verification as there are no isolated plants, no municipal roads, and only some 900 distinct properties. These may all be treated as electrical, for at this moment what remains of the horse and cable systems has begun the process of conversion. These roads, created by the genius of Sprague, Van Depoele, Henry and others, represent at the present time a capitalization of over $1,800,000,000, which, increasing of late at a rate of over $150,000,000 per year, will cross the two billion mark early this year, if, indeed, it has not already done so. Seriously inflated and overcapitalized as many of these roads have been, they yet have conferred such solid benefits on the community that the values are generally sound and sure of appreciation. In 1897 these roads were earning $150,000,000 gross, and in 1898 only 220 of them showed not less than $130,000,000, gaining very materially on this figure in the next year. Estimating that the gross earnings bear the proportion of about 10 per cent to the gross capitalization, therefore, the earnings would be $180,000,000 last year. Allowing, next, 60 per cent for all operation expenses, there was a net of $72,000,000, or exactly 4 per cent return over the whole vast sum. No inclusion is made in this total of such costly work as that done by the Baltimore & Ohio Railroad, or of the large investment in mine electric railways.

Already the three billion point in the calculation has been reached and surpassed, but there are additional items to be considered. Allusion has been made to mining work, quite a class by itself, and millions have been spent on transmission lines in connection with it. Those most familiar with the field estimate a valuation of $100,000,000, based on the few plants within their immediate knowledge. Then comes an analogous class of work in power plants for factories, mills, printing offices, etc., and inclusive of such enterprises as those at

Niagara, where $10,000,000 is a moderate allowance for the power features alone. Power plants blend frequently into those for lighting, but a safe figure for them separately is another $100,000,000 to $150,000,000. Yet a third kindred group of industries is furnished by those for electrolytic deposition. The latest returns show that in copper treatment alone some 200,000 tons of electrolytic are now produced annually in the United States of America, with 170,000 ounces of gold and 21,000,000 ounces of silver as by products. With deposition work again may be noted nearly 500 electroplating establishments with a capital investment of $50,000,000. It would be hard to-day to find a home in America that has not some electroplated articles in it.

Thus far nothing has been said of the electrical manufacturing companies in all the different fields. The General Electric and Westinghouse alone stand for $50,000,000, but they cannot be bought for that figure; and there are forty other concerns of the same class, many of them large, making light and power apparatus, to say nothing of the lamps and fittings. In the telegraph and telephone branches a list of 100 producers can be run up, some of them quite extensive, and to them can be added a score of makers of wire and cable, nearly all with large plants. The futile efforts that have been made to bunch such plants in different lines have proven that a sum of $150,000,000 for the electrical manufacturing industries of America would be unduly moderate, especially if they were taken in at their own valuation. To all these must be added the new group of automobile producers and local companies, with an investment of at least $10,000,000, and a capital on paper many times that amount. The storage battery industry, too, has come to pay dividends on $15,000,000; and the latest development, telpherage, bids fair to roll up millions almost as promptly as any of its predecessors have done.

There are various distributive agencies quite aside from the telegraph, telephone and lighting companies, and quite apart from the traction properties. From 100 to 125 concerns are entitled to the name of wholesalers, or jobbers, and when the retail point is reached, the numbers increase most rapidly. In the aggregate the hundreds of electrical contractors, bell hangers, hardware stores, bicycle shops, etc., dispose of immense quantities of small apparatus. A hotel of any pretensions has its annunciators, telesemes, pan-signals; and hundreds of thousands of homes have their bells, push-buttons, and batteries. Annual renewals, repairs and extensions are considerable. There is, moreover, a very large annual business in the repairs of electric light and power apparatus, and it seems difficult to get any of it finally into the scrap heap. There is quite another class of utilization of electrical apparatus in universities, schools, hospitals, electrotherapeutic work, etc. The list again is well nigh endless of concerns making instruments, batteries, special appliances, and nearly every one of them would scorn to be capitalized at the amount of the first telegraph company.

One is often asked how many people are employed in the electrical industries of the country, but it is a matter difficult to determine. There are over 100,000 in telegraphy in its various branches. The Bell telephone exchanges have to-day over 26,000 employees. Electric lighting, with its large power plants, linemen, wiremen, executives, etc., probably gives employment to 150,000 people. The electric railways, with their service all around the clock, need a numerous force, possibly 150,000. The electrical factories, all told, must have 100,000 hands; three companies alone have 25,000; while scores and scores range from 100 up to 500. A lumping together of all the miscellaneous forces would bring the total above 600,000. It is usually said that over 500,000 souls derive a living directly in the United States from electricity, and that number is certainly below the mark rather than above it.

The above data are available to all and can be tested and checked by any one who deems it worth while. If the estimates are lopped on one side, they expand on another, and it is submitted that there is no escape from the conclusion that upon any fair and reasonable basis of calculation the American people have invested during the past one hundred years enough money to create electrical industries whose values approximate three billions of dollars. The summation of the above is as follows: Telegraphy, $250,000,000; telephony, $300,000,000; electric lighting, $1,200,000,000; electric railways, $1,800,000,000; electric mining, power transmission, deposition and plating, $250,000,000; electric manufacturing, $150,000,000; automobiles and storage battery, $25,000,000—grand total, $3,975,000,000. In other words, four billions is not out of the way, and at the worst must be taken as a plausible and flattering guess—forty million dollars for every year of the century.

Welcoming the Stranger.

An elaborate reception to the new century was given by the City of Greater New York at the City Hall, when a chorus of 1000 singers and a large band competed with 100,000 fishhorns and were extinguished. It was not so easy, however, to obscure the effect of the beautiful illuminations, all of which were electrical. The handsome old building was festooned in strings and designs of colored lamps—red, white and blue—of which 3690 of 10 candle-power were used. A sign reading "Welcome Twentieth Century, 1900-1901," containing 560 lights, was placed over the main balcony. The entire installation was done within 48 hours after the order was received, by the Norden Electric Works, under the supervision of Mr. Mortimer Norden. Just before midnight the lights were cut off, leaving the building in darkness, and then as the century border line was crossed they were all flashed in again, the same effect being repeated by the lights on the *World* dome. For about an hour the City Hall remained the center of a wonderful picture, as colored fires were burning in every direction, throwing it into high relief.

A New Century Call-Up from Mars.

It will be remembered that Mr. Nikola Tesla has for some time past insisted on the possibility of exchanging signals with Mars, as determined by the results of his interesting experiments on wireless transmission. The New York *Sun* publishes on Jan. 3 a column interview with him on the subject and in it asserts that he has recently seen some curious effects on his apparatus. We quote as follows: "When the National Red Cross, which was arranging for the end try, asked Mr. Tesla to indicate what, in his opinion, would be one of the century meetings of its various branches throughout the countransmission. The New York *Sun* publishes this week a column inof the great achievements of the coming century, he gave just a hint of one of the wonders he discovered in Colorado. In a more elaborate way Mr. Tesla dwelt on his work to a *Sun* man. He regards his latest results as far and away the most important he has ever attained. Briefly, Tesla has been able to note a novel manifestation of energy, which he knows is not of solar or terrestrial origin, and, being neither, he concludes that it must emanate from one of the planets. While he was conducting his investigations in his Colorado laboratory one day the instrument he was using to observe the electrical condition of the earth was affected in an unaccountable manner. It recorded three distinct, though very faint movements, one after the other. These movements were observed not once, but many times, the number of impulses varying, and Mr. Tesla now firmly believes that, with improved apparatus, it will be quite possible for the people of the earth to communicate with the inhabitants of other planets."

CURRENT NEWS AND NOTES.

NIAGARA POWER IN TORONTO.—A party of Toronto (Ont.) capitalists recently consulted with Mr. William B. Rankine, of Niagara Falls, N. Y., regarding the transmission of electrical power to the City of Toronto. While the details have not yet been made public, it is said that arrangements are being made to transmit the power from the American side to Toronto at an early date. The development of power on the Canadian side was also discussed.

TESLAIC TELEGRAPHY.—A special dispatch from Washington, of Dec. 29, says: "Nikola Tesla has been asked by Rear Admiral R. B. Bradford, Chief of the Bureau of Equipment, to submit for trial a wireless telegraphy system perfected by him. Mr. Tesla says that his system is equal to, and perhaps superior to that of Marconi, and has offered to install it on naval vessels. Admiral Bradford in his last annual report recommended that negotiations be entered into with Marconi to secure his system for American vessels of war, if a reasonable rate could be agreed on."

UNDERGROUND RAILWAY VIBRATION.—A cable dispatch from London, of Dec. 29, says: "The promoters of the underground electric transit tube projects are still sorely troubled by the vibration difficulty. Householders in Bayswater, where the twopenny tube runs eighty feet below the surface, have had photographs taken in their drawing-rooms while trains were passing, producing an effect as though the walls were trembling. The tube engineers are conferring to find means of correcting the vibration, as failure to do so may prove fatal to all the other tube projects now hatching."

WIRELESS TRANSMISSION OF POWER.—A London dispatch dated Dec. 22 states that Prof. J. A. Fleming is understood to be engaged in important experiments in connection with a novel mode for the transmission of electrical energy. There is reason to believe, the dispatch states, that the professor has discovered the means by which such power can be distributed without wires.

POWER FOR PHILADELPHIA.—It is stated by the local newspapers that Philadelphia capitalists have under consideration a plan to employ water power as a substitute for steam in the production of electricity. The Susquehanna, the Patapsco, the Delaware and the Schuylkill have all been suggested, any one of which would be adaptable.

DEATH OF LORD ARMSTRONG.—The death is announced from England of Lord Armstrong, the great inventor and builder of implements of war, etc. From his youth he was interested in science, and his development of the hydroelectric machine, obtaining electricity from the discharge of a jet of steam, and developing the phenomena connected therewith, won him his fellowship in the Royal Society. His next invention was an electric crane, but he soon after turned his attention more especially to hydraulics, war material, etc., creating the Elswick Works, one of the most notable places of the kind in the world.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The 149th meeting of the American Institute of Electrical Engineers has been postponed to Wednesday, Jan. 9, 1901, when it will be held in connection with an institute dinner at Muschenheim's, 41 West Thirty-first Street. The dinner will take place at 7 o'clock p. m. The topic for discussion after dinner will be "Electricity in the Last Century and in This." Several members of the institute will speak on this subject. Secretary Pope would like to hear from members who expect to attend the dinner, in order that proper arrangements may be made. The attendance promises to be large.

MANUFACTURE OF ALUMINUM IN CANADA.—Mr. J. W. Hill, of Toronto, Ont., has been for the past eight months engaged in the construction of the works for the reduction plant of the Pittsburg Reduction Company at Shawinigan Falls, Quebec. Mr. Hill says that the company intends to go into the manufacture of aluminum. This is the first establishment of the kind in Canada, and the Pittsburg company went to the Canadian side because of the corundum deposits. The reduction works, which were built at a cost of $250,000, will be operated by electricity generated at Shawinigan Falls, which are three miles north of the city of Three Rivers, Quebec.

A NEW LABOR UNION.—It is stated that a new national labor organization has been formed, with headquarters in Chicago. The new body is the Gas and Electric Fitters' National Association of America. Its object is to effect an amalgamation of the lighting trades so that internal dissensions over trade jurisdiction may cease. The Gas-Fitters' Unions in Cincinnati, St. Louis, Boston and New York have been in communication with the local union and have applied for charters of affiliation. The idea of amalgamation is in line with the policy laid down by the American Federation of Labor as a means of settling disputes which come before that body at every convention relative to the classification of work.

THE AUTOMOBILE BUS FAD.—The new electric opera bus of the Lakewood Hotel, in the Jersey pine woods, designed to meet the incoming guests at the railway station, bids fair to be put to other than the use for which it was intended, as it has become quite a fad and is in great demand for riding parties. It is difficult for the residents of large cities to understand the awe with which the denizens of this little village among the pines regard the horseless vehicle. Lakewood is but one and one-half hours' journey from New York, yet the natives gaze in open-eyed amazement at the "new-fangled" carriages of the Lakewood Hotel when they go speeding along the forest drives, and many of them have not conquered their feeling of mistrust.

CONNECTICUT TROLLEY SCHEMES.—The trolley projects for which legal notice has been given to the coming State Legislature already nearly equal the 500 single-track miles of operated trolley roads in the State. They represent all classes of roads—cross-country, parallels of steam roads, parallels of other trolleys and roads through many city streets which existing trolley companies are trying to preëmpt. In a number of cases several trolley applicants are seeking substantially the same layout, and there is good reason to believe that in certain instances the New Haven Railroad Company is behind some of the projects, in order to head off threatened parallels. The number and distances of the layouts probably equal, if they do not exceed, those of the great "trolley year" of 1893 in the State.

ELECTROLYTIC REDUCTION OF COPPER.—In a patent issued Dec. 25 to James Douglass, a process is described for reducing copper ore matte, which consists in electrolyzing solid cuprous-chloride and employing the resulting gases for the reduction of the copper. As illustrated, a closed vat is about one-half filled with solid cuprous-chloride with a cathode inserted in the mass. The anode is submerged in the electrolyte above the solid cuprous-chloride. The electrolyte consists initially of water acidified with hydrochloric acid to render it conductive, but normally consists of cuprous-chloride, an acid solution of the gases evolved, and of various compounds of copper and other metals. The copper ore matte is placed in an exterior vessel and is dissolved by chlorine evolved from the electrolytic separation of the cuprous-chloride in the first mentioned vat.

A LITTLE BILL FOR CABLE TOLLS.—Members of the Red Cross Society are considerably concerned over the report that the organization will be compelled to pay in the neighborhood of $11,000 in cable tolls for "peace" messages sent to the United States from important personages and rulers of other countries. Delays in the mails and on the part of the senders have necessitated cabling the messages in order that they reach New York in time for general distribution throughout this country. The messages of the Emperor of Japan and Pope Leo have been sent by cable and others are now in transmission. Each message contains about 400 words, and the unexpected expense falls heavily on the organization. There are forty-seven nations recognizing the Geneva treaty, and the Red Cross, and each of these has contributed one or more greetings to the people of the United States, the messages coming from rulers and representative men and women. It is said there will be war in the society over these peace messages, but cable companies have to earn a living and are just now doing so.

PIANO ELECTRICAL ATTACHMENT.—At a recent meeting of the Franklin Institute music was furnished by a piano fitted with the "Electrochord," an attachment invented by Lieut. Geo. W. Breed, formerly of the United States Navy, and which enables the performer to sustain the tones of the instrument as in the flute or violin. Connected with the keyboard is a row of delicate electrical contacts, so light in their action as to be unnoticeable in the touch of the keys, and connected with these is a row of little electromagnets in front of the strings. Whenever a key is depressed a current is sent into the corresponding magnet, which, by its consequent intermittent attraction sets its string in vibration and keeps it in vibration as long as the key is held down, thus producing a prolonged singing and pleasing note. The performer turns the current on or off by means of a knee swell. When this knee swell is not pressed there is no electrical action, and the piano may be played as usual, there being no stiffening of the piano action or damping of the tone due to the electrical apparatus. Just below the keyboard there are four little pearl-tipped push buttons, which correspond to the stops of an organ. When one of these is pressed a single note of any chord struck is sustained with a musical effect similar to that of a violin or flute accompanied by the piano; with another push button, all the notes of each chord struck are sustained with flute-like tones; with a third, they are all soft, sweet and melodious, while with a fourth the highest note of each chord is held with a tone very similar to that of a flute, and the lower notes play a soft accompaniment. Beautiful effects are obtained by pressing down the keys without allowing the hammers to touch the strings, which are set in vibration by the magnetic forces alone. There is no material change in the appearance of the piano, the only new feature visible from the outside being the row of push buttons previously referred to, and the knee swell, which is a neatly made bronze lever colored to match the piano case, and which folds up out of sight when the piano is not in use. This attachment, which is relatively inexpensive, may be applied to any piano.

Symbols for Physical Quantities and Abbreviations for Units.

Recommended by the Committee on Notation of the International Electrical Congress of 1893, with additions of the International Electrical Congress of 1900.

Physical Quantities.	Symbols.	Defining Equations.	Dimensions of the Physical Quantities,	Names of the C. G. S. Units.	Abbreviations of the Names of the C. G. S. Units.	Practical Units.	Abbreviations of the Practical Units.
Fundamental.							
Length	L, l	.....	L	Centimetre.	cm	Metre.	m
Mass	M	.....	M	Mass of one gramme.	g	Mass of a kilogramme.	kg
Time†	T, t	.....	T	Second.	s	Minute; hour.	m; h
Geometric.							
Surface	S, s	$S=LL$	L^2	Square centimetre.	cm^2	Square metre.	m^2
Volume	V	$V=L.L.L$	L^3	Cubic centimetre.	cm^3	Cubic metre.	m^3
Angle	α, β	$\alpha=\frac{\text{arc}}{\text{radius}}$	A number.	Radian.	.....	Degree; minute; second; grade.	
Mechanical.							
Velocity	v	$V=\frac{L}{T}$	LT^{-1}	Centimetre per second.	cm : s	Metre per second.	m : s
Angular Velocity	ω	$\omega=\frac{v}{L}$	T^{-1}	Radian per second.	.....	Revolutions (turns) per minute.	t : m
Acceleration	a	$a=\frac{v}{L}$	LT^{-2}	Centimetre per second per second.	$cm : s^2$	Metre per second per second.	$m : s^2$
Force	F, f	$F=Ma$	LMT^{-2}	Dyne.	dyne	Gramme; kilogramme.	g; kg
Work	W	$W=FL$	L^2MT^{-2}	Erg.	erg	Kilogrammetre.	kgm
Power	P	$P=\frac{W}{T}$	L^2MT^{-3}	Erg per second.	erg : s	Kilogrammetre per second.	kgm : s
Pressure	p	$p=\frac{F}{S}$	$L^{-1}MT^{-2}$	Barie.	$dyne : cm^2$		
Moment of Inertia	K	$K=ML^2$	L^2M	Gramme-mass-centimetre-squared.	$g\text{-}cm^2$		
Magnetic.							
Strength of Pole	m	$F=\frac{m^2}{L^2}$	$L^{\frac{3}{2}}M^{\frac{1}{2}}T^{-1}$				
Magnetic Moment	$\mathfrak{M}$	$\mathfrak{M}=ml$	$L^{\frac{3}{2}}M^{\frac{1}{2}}T^{-1}$				
Intensity of Magnetization	$\mathfrak{I}$	$\mathfrak{I}=\frac{\mathfrak{M}}{V}$	$L^{-\frac{1}{2}}M^{\frac{1}{2}}T^{-1}$				
Field Intensity	$\mathfrak{H}$	$\mathfrak{H}=\frac{F}{m}$	$L^{-\frac{1}{2}}M^{\frac{1}{2}}T^{-1}$	Gauss.	.....	Gauss.	
Flux of (Magnetic) Force	Φ	$\Phi=\mathfrak{H}S$	$L^{\frac{3}{2}}M^{\frac{1}{2}}T^{-1}$	Maxwell.	.....	Maxwell.	
Magnetic Induction	$\mathfrak{B}$	$\mathfrak{B}=\mu\mathfrak{H}$	$L^{-\frac{1}{2}}M^{\frac{1}{2}}T^{-1}$	Gauss.	.....	Gauss.	
Magnetizing Force‡	$\mathfrak{H}$	$\mathfrak{H}=\frac{4\pi NI}{L}$	$L^{-\frac{1}{2}}M^{\frac{1}{2}}T^{-1}$				
Magnetomotive Force	$\mathfrak{F}$	$\mathfrak{F}=4\pi NI$	$L^{\frac{1}{2}}M^{\frac{1}{2}}T^{-1}$	*Gilbert.**	.....	1 *Gilbert**=0.7958 ampère-turns	a-t
Reluctance (Magnetic Resistance)	$\mathfrak{R}$	$\mathfrak{R}=\frac{L}{S}$	L^{-1}	*Oersted.**	.....	*Oersted.**	
(Magnetic) Permeability	μ	$\mu=\frac{\mathfrak{B}}{\mathfrak{H}}$	A number.				
(Magnetic) Susceptibility	κ	$\kappa=\frac{\mathfrak{I}}{\mathfrak{H}}$	A number.				
Reluctivity (Specific Magnetic Resistance)	ν	$\nu=\frac{1}{\mu}$	A number.				
Electromagnetic.							
Resistance	R, r	$R=\frac{E}{I}$	LT^{-1}	.....	.....	Ohm.	ohm
Electromotive Force	E, e	$E=RI$	$L^{\frac{3}{2}}M^{\frac{1}{2}}T^{-2}$	.....	.....	Volt.	v
Difference of Potential	U, u	$U=RI$	$L^{\frac{3}{2}}M^{\frac{1}{2}}T^{-2}$	.....	.....	Volt.	v
Intensity of Current	I, i	$I=\frac{E}{R}$	$L^{\frac{1}{2}}M^{\frac{1}{2}}T^{-1}$	.....	.....	Ampère.	
Quantity of Electricity	Q, q	$Q=IT$	$L^{\frac{1}{2}}M^{\frac{1}{2}}$	.....	.....	Coulomb; ampère-hour.	c; a-h
Capacity	C, c	$C=\frac{Q}{E}$	$L^{-1}T^2$	.....	.....	Farad.	F
Electric Energy	W	$W=EIT$	L^2MT^{-2}	.....	.....	Joule; watt-hour.	J; w-h
Electric Power	P	$P=EI$	L^2MT^{-3}	.....	.....	Watt; kilowatt.	w; kw
Resistivity (Specific Resistance)	ρ	$\rho=\frac{RS}{L}$	L^2T^{-1}	.....	.....	Ohm-centimetre.	ohm-cm
Conductance	G, g	$G=\frac{1}{R}$	$L^{-1}T$	.....	.....	Mho.	mho
Conductivity (Specific Conductance)	γ	$\gamma=\frac{1}{\rho}$	$L^{-2}T$				
Coefficient of Induction (Inductance)	L, l	$L=\frac{\Phi}{I}$	L	.....	.....	Henry.	H
Frequency	n	.....	Numeric.	.....	.....	~	
Admittance	Y	$Y=\frac{1}{Z}$	$L^{-1}T$ ‡‡	.....	.....	Mho.	mho
Impedance	Z	$Z=\sqrt{R^2+X^2}$	LT^{-1} ‡‡	.....	.....	Ohm.	ohm
Reactance	X	$X=2\pi nL$ or $-\frac{1}{2\pi nC}$	LT^{-1} ‡‡	.....	.....	Ohm.	ohm
Susceptance	B	$B=\sqrt{Y^2-G^2}$	$L^{-1}T$ ‡‡	.....	.....	Mho.	mho

*Name provisionally adopted by the American Institute of Electrical Engineers.

†The International Bureau of Weights and Measures has established an important distinction in the notation of time, according as it refers to the *epoch* (date or time of day) or the *duration* of a phenomenon. In the former case the reference letters are used as indices, and in the latter they are on the same line with the numbers; for instance, an experiment began at $2^h\ 15^m\ 46^s$, lasted 2h. 15m. 46s., and ended at $4^h\ 31^m\ 32^s$. This method is to be recommended.

‡N is the number of turns, and L the length of the solenoid generating the magnetizing force. ‡‡Plane Vector Quantity.

LETTERS TO THE EDITORS.

Variable Ratio of Rotary Converters.

To the Editors of Electrical World and Engineer:

Sirs:—In your Digest of Dec. 8, 1900, a leading place is given to the description of a method for "Varying the Secondary Voltage of a Converter," which is attributed to the General Electric Company, of Berlin. The arrangement shown and described appears to be identical with that introduced by the writer some five and a half years ago, and which forms the subject of English Letters Patent No. 11,153, 1895. Claim 2 of this patent is as follows:

"A rectifying motor generator transformer with main and axuiliary armature cores and magnetic field arranged and wound to afford means for varying the transforming ratio by manual or equivalent regulation, all substantially as and for the purposes hereinbefore described."

Fig. 5 of the same shows a construction precisely the same as that illustrated by you. W. L. SPENCE.

GLASGOW, Scotland.

The Rectifier System in England.

To the Editors of Electrical World and Engineer:

Sirs:—We have read with great interest the article by Mr. F. H. Minshall on "Street Lighting by Electric Lamps" in your issue of Dec. 1, and, while congratulating him on the able manner in which he has treated his subject, we should like in justice to ourselves, to point out one instance where his figures are not quite up to date. As we are the sole makers of the Ferranti patent rectifier, three of which we have supplied to Croydon, we beg to draw attention to the fact that the efficiencies quoted are very much below what can now be attained. The Croydon rectifiers, though at the time the best our experience could devise, were built about five years ago, and owing to this and the fact that their output is only 30 lights, *i. e.*, 18 kilowatts, it is quite probable their full load efficiency is only 85 per cent. However, during the last three or four years, great progress has been made, and on a test made in last May on our latest design of rectifier, the output being 50 lights, i. e., 30 kilowatts, the following good results were obtained:

Full load, 91.3 per cent efficiency; one-half load, 84.2 per cent.

An advance has therefore been made of 6.3 per cent on the full load efficiency. This increase of efficiency reduces the cost of a 550-watt rectifier current open arc $5 per year, making the total cost $102.03 per year. This brings the cost below either of the 650-watt alternating current enclosed arcs mentioned, and there is no question that the 550-watt rectified arc of 11.8 amperes gives by far a better light than a 650-watt alternating enclosed arc.

Another point we would wish to draw attention to is that the synchronous motor has been partially redesigned, and the running improved to such an extent that its liability to run out of synchronism is of rare occurrence, and we are assured by two electric light stations where our new pattern rectifiers have been in use continuously for nearly two years that a run out has never occurred.

We have written this explanation as it may be inferred that Mr. Minshall's results are the latest obtainable from the rectifier system, and it is possible some engineers may in consequence be prejudiced against it. S. Z. DE FERRANTI, Ltd.

HOLLINWOOD, England.

DIGEST
OF
CURRENT ELECTRICAL LITERATURE.

DYNAMOS, MOTORS AND TRANSFORMERS.

Large Alternators.—HEYLAND.—The first parts of an illustrated article giving "Some notes on the design of large alternators" of the fly-wheel type, with special reference to two 1000-hp alternators exhibited at the Paris Exposition by the Electricité et Hydraulique, Ltd., of Charleroi. He thinks that no machines of their type have hitherto been built having such small pressure drop. The good results obtained with these two machines are due first to various electrical details, but principally to the high magnetic saturation in the poles, combined with a very small increase of magnetic leakage from no load to full load. The total weight of one of these machines complete, but without the shaft or bearings, is 42.2 tons, which gives 126 lbs. of total material per kilowatt, of which 7.3 lbs. is copper. The field poles are bolted directly to the rim of the magnet wheel without being let in in any way, as is frequently done in order to decrease the magnetic reluctance between the two surfaces; this construction was unnecessary, as the magnetization of the iron is carried to a very high value, and the paths for the lines of force are very short. The poles themselves are unusually short in order to minimize the magnetic leakage between them; moreover, the leakage path is still further lengthened, owing to the fact that the poles are of comparatively small section, the reduced section being possible on account of the high flux density in the poles and on account of the high permeability of the cast-steel used. The armature windings are in closed slots, the depth of these slots being made small in order to reduce as much as possible the magnetic leakage that occurs in the teeth between them. The closing of the slots, on the other hand, has the effect of causing considerable magnetic leakage of the flux from the poles across the slot bridges, which are about 1-12 in. deep, but this leakage does not alter much with the load. There is at every load a strong leakage across these bridges, to such an extent that at no load (with excited magnets) the bridges are already saturated and therefore the magnetic reluctance is constant. He gives in two diagrams the magnetization curve and the short circuit current curve. He discusses these curves and shows that the smallness of the pressure drop is due in a great measure to the high saturation in the field poles and air gap. While with ordinary machines an increase of the air-gap diminishes the pressure drop, with his type of alternators this effect is inconsiderable. The advantage of a saturated field is thus of even greater value with diminished air-gap length, or, what is the same thing, when a large portion of the excitation is required for the iron circuit alone. This is especially the case with small machines.—Lond. *Elec. Rev.*, Dec. 7, 14. An illustrated description of these alternators also in *Elek. Zeit.*, Dec. 6.

REFERENCES.

Testing of Alternating Current Machinery.—TOWNSEND.—An outline of a series of experiments which make up the alternating current laboratory course prescribed for the fourth-year students in the electrical engineering department of Columbia University. In addition to most of the usual commercial tests, a number of experiments are given which are designed solely to point out and explain the characteristic properties of the apparatus used. The experiments relate to the elementary properties of alternating circuits, alternating

JOURNALS ABSTRACTED FOR THE DIGEST.—The following is a list of the more important abbreviations used in the Digest for the titles of the electrical journals referred to. There are many other journals which are abstracted and noticed from time to time, the titles of which are either given in full or are abbreviated in such a way as to be easily recognized:

AUSTRIAN.		
Electro-Techniker.	*Elec. Tech.*	Vienna
Elektrotechnischer Neuigkeits-Anzeiger.	*Elek. Neu. Anz.*	Vienna
Zeitschrift fuer Elektrotechnik.	*Zeit. fuer Elek.*	Vienna
BELGIAN.		
Bulletin of the Belgian Society of Electricians.	*Bul. Belg. Soc. Elec.*	Liege
BRITISH.		
Abstracts of Papers in Scientific Transactions.	*Abstracts Brit.*	London
Electrician.	*Lond. Elec.*	London
Electrical Review.	*Lond. Elec. Rev.*	London
Electrical Engineer.	*Lond. Elec. Eng.*	London
Electricity.	*Lond. El'ty.*	London
Electrochemical Review.	*Electrochem. Rev.*	Manchester
Lightning.	*Lightning*	London
Philosophical Magazine.	*Phil. Mag.*	London
Proceedings of Institution of Civil Engineers.	*Inst. Civ. Eng.*	London
Science Abstracts.	*Science Abstracts.*	London

current generators, alternators in parallel, transformers, curve tracing, resonant rise of potential, polyphase circuits and transformations, test of a three-phase induction motor, converters.—*Sch. Mines Quart.*, Nov.

Motor Generators and Synchronous Converters.—Perkins.—A continuation of his illustrated serial. He discusses the use of motor generators for series arc lighting circuits in streets, the most practical form and that most extensively used being to drive an arc lighting machine at each end of an alternating current motor shaft. He then discusses the use of rotaries for electrolytic work, in combination with step-down transformers of a variable ratio of transformation; he describes the installation of several electrolytic plants at Niagara Falls.—*West. Elec.*, Dec. 22.

Lights and Lighting.

Direct Current Arc.—Duddell.—The first part of a paper read before the Brit. Inst. Elec. Eng. on "Rapid variations in the current through the direct current arc" (not arc lamp, as that involves the mechanism). He gives an account of what occurs when the current is periodically varied more or less rapidly over a range which is very small compared with the mean value of the direct current. He distinguishes between the two cases whether the variation of the current is due to changes taking place in the circuit, such as variations in e. m. f. or resistance, or due to effects in the arc itself, such as hissing, humming. In considering the first case, he discusses the effects produced by variations of the current on the potential difference, on the light emitted, on the craters and on the vapor column; he shows that the direct current arc may be used as a telephone receiver and even as transmitter, as it is affected by such small changes of outside conditions as sound waves produce. He then discusses the variations of the current due to humming and hissing. In the humming arc the frequencies of the rotation of the arc and of the variations in the p. d. current, and light emitted in a given direction, are identical with the pitch of the note given out. When the current through the humming arc is increased until the arc hisses, the variations in p. d. current and light change in a very striking manner from regular periodic variations to very irregular variations, which, however, can be separated into a large comparatively slow variation and a rapid superimposed one; the rapid variations of p. d. and current correspond with the variations of the light emitted by the positive crater, and the large slow variations with the rotation of the arc as a whole. In many cases the maximum light and minimum p. d. occur practically at the same instant, while the maximum current occurs later than the light maximum. This is the opposite to what occurs when the current through the arc is varied by any change in the circuit, for in the latter case the maximum current occurs before the light maximum. He then discusses sounds emitted by very short and very long arcs; also intermittent arcs.—Lond. *Elec.*, Dec. 14.

Train Lighting.—Clark.—An illustrated description of a system devised by him for electric passenger coach lighting. It belongs to those systems in which the current is produced by an axle-driven dynamo and a storage battery. The dynamo has two windings on the armature, one for the storage battery and the other for the lamp direct. To keep the voltage constant under variation of speed, a voltage regulator is used, in which a rheostat is actuated by a centrifugal governor. A special electromagnetic switching device is in use for making the necessary connections between lamps, battery and dynamo; also a special device for reversing the shunt field winding of the dynamo when the direction of the motion of the car is reversed. These devices are fully described and illustrated.—*West Elec.*, Dec. 22.

Arc Lighting in Chicago.—An illustrated article on the new municipal arc lighting plant in Chicago. It contains four Brush 160-light arc machines, each giving 9.6 amperes at 8000 volts and running at 500 revolutions; there are five Gen. El. arc machines of the double circuit type, each giving 6.6 amperes at 11,000 volts, the speed being 500. The present equipment provides for 1200 lights, 831 lamps being now used. Seven series circuits are supplied from the station.—*West. Elec.*, Dec. 22.

Power.

Electric Power in the Comstock Mines.—Two papers on the Comstock mines, which are extremely rich in gold and silver ores, but had to be abandoned in spite of strenuous efforts twenty years ago, as the pumping of the water could not be accomplished successfully. The first paper, by Eckart, gives a description of the historical pumping plants, erected at the Comstock mines up to 1884 and 1886. The second paper, by Low, deals with the Truckee-Comstock power transmission, by which it is hoped the resurrection of the Comstock mines will be accomplished. The contract of the mining companies with the electric transmission company requires the latter to maintain a 2240-volt three-phase service for 1500 horse-power, which shall be measured in the sub-station at Virginia City. The water power plant and the transmission lines are described; the current is transmitted at 22,000 volts. At the mines, electric hoists will be installed, using the balanced tail-rope system, driven by direct-geared 200-hp induction motors. Current for the underground stations is carried down the vertical shaft of the Consolidated California and Virginia to the 1750-ft. level by means of a three-conductor, lead-encased cable, protected by a steel wire armor. A 100-ton mill with two sets of grinders and three sets of concentrators is equipped with six induction motors. Ore from the Gould & Curry mine is brought to the mill by a small direct current haulage equipment, to which current is furnished by a 220-volt direct current generator belt driven from an induction motor.—*Jour. of Elec.*, Nov.

Power from Blast Furnace Gases.—A brief illustrated article on a new installation at the Sheepbridge Iron Works of Chesterfield. Gas given off from the blast furnaces is treated in a Thwaite-Gardner installation and supplied to a 100-hp gas engine driving a dynamo, which gives current for lighting and power purposes. The success of the installation was dependent upon its being capable of running continuously. This has been so successfully done that the system is now being extended.—Lond. *Elec. Rev.*, Dec. 14.

Traction.

Electric Traction on Main Lines.—The long abstract of the discussion which followed Langdon's recent paper is concluded. There is also an editorial in this paper. Langdon compared actual steam railroading costs with estimated electrical railroading costs on a certain line; for the electric traction he had assumed conditions which are only theoretical; he ignored the additional energy and cost evolved in acceleration and hill climbing, and assumed a perfectly level track, without any intermediate stops or starts; it is said that a proper consideration of actual working conditions would considerably increase Langdon's estimate of capital outlay and working cost. The greater part of the discussion was devoted simply to the question of replacing the steam locomotive by the electric locomotive, heavy trains being drawn by a separate locomotive at comparatively lengthy intervals of time. This is called a narrow view of the question and attention is called to the declaration of F. J. Sprague that the claims of electric traction involve far more than the mere supersession of the steam locomotive, and that the fact that electricity permits of a faster and more frequent service, may in the end prove even a greater inducement to its adoption by the railway companies than the bare question of relative cost. Electricity cannot only supply cheaper traction than steam; it can accomplish things that steam cannot by any means be made to do. "Electric traction will not be merely a superior thing; it will be the only thing possible. But much must happen before that time arrives."—Lond. *Elec.*, Dec. 14.

Battery Traction.—A note on the experience had in Ghent, Belgium. About a year ago the tramway company decided to adopt electric traction, disposed of its horses and introduced accumulator cars, for, as the town is composed of 26 islands, with 140 bridges, the difficulty of an overhead system was very great and an underground one was practically out of the question. The experiment was undertaken by

Canadian.		
Canadian Electrical News.	*Can. Elec. News*	Toronto
French.		
Bulletin de la Société Internationale des Electriciens.	*Bul. Soc. Int. des Elec*	Paris
Cosmos.	*Cosmos*	Paris
L'Industrie Electrique.	*L'Ind. Elec*	Paris
L'Eclairage Electrique.	*L'Eclairage Elec*	Paris
L'Electricien.	*L'Elec.*	Paris
L'Energie Electrique.	*L'Energie Elec*	Paris
La Nature.	*La Nature*	Paris
Le Mois Scientifique et Industriel.	*Le Mois Sc. Ind*	Paris
L'Industrie Electro-Chimique.	*L'Ind. Electro-Chimique*	Paris
Revue Generale des Sciences.	*Rev. Gen. des Sc*	Paris
German.		
Centralblatt fuer Accumulatoren und Elementenkunde.	*Centralblatt f Accum*	Halle
Elektrotechnische Zeitschrift.	*Elek. Zeit*	Berlin
Elektrotechnischer Anzeiger.	*Elek. Anz*	Berlin
Elektrochemische Zeitschrift.	*Electrochem. Zeit*	Halle
Physikalische Zeitschrift.	*Phys. Zeit*	Leipzig
Elektrotechnische Rundschau.	*Elek. Rund*	Frankfurt
Zeitschrift fuer Beleuchtungswesen.	*Zeit. f. Beleucht*	Berlin
Zeitschrift fuer Elektrochemie.	*Zeit. f. Elektrochemie*	Halle
Japanese.		
The Electrical Friend.	*Elec. Friend*	Tokyo

two companies, one undertaking the exploitation of the line and the other the station for charging the accumulators. The trial is said to have been a failure, but it is not stated in this note why. Despite the enormous difficulties in the way, the company now proposes to construct an overhead system save over the bridges where this is impossible, and where the accumulators will be retained.—Lond. *Elec. Rev.*, Dec. 14.

ELECTRO-PHYSICS AND MAGNETISM.

Cosmic Electric Phenomena.—G. T. FITZGERALD and O. LODGE.—Two communications. FitzGerald refers to Lodge's recent letter. He points out that there are many things which seem to show that comets' tails, auroræ, the solar corona, and cathode rays, are closely allied phenomena. Regarding Cremieu's experiments made to show that there is no magnetic field due to a moving electric charge, he suggests a possible but highly hypothetical way of reconciling these experiments with a great deal of our existing observations and theories. He further remarks that until Cremieu's experiments have been repeated by others, and until no doubt can be thrown on their methods or calculations, he would advise at least a suspension of judgment before we seek for new foundations for our electromagnetism. In the other communication Lodge says that the conditions of a vacuum tube seem to correspond closely with the conditions which must obtain in inter-planetary space; if the sun or other body is negatively electrified, cathode rays can hardly help streaming from it through the great dark space; when they impinge on an atmosphere they should give rise to ordinary vacuum tube appearances, etc. In the question of the disturbances of magnetic observatories by tramways, he says that so far as waste tram-electricity disturbs observatories, he is with the observatories. He says that it would be madness to discontinue or spoil the record of a long series of continuous observations except in case of dire necessity, and that the destruction or removal of Kew would be a national misfortune.—Lond. *Elec.*, Dec. 14.

E. M. F. Due to the Motion of a Liquid.—ZAKRZEWSKI.—An illustrated description of the following experiment: Two basins, containing water, are in communication with another by a capillary glass tube, the inner surface of which is silver plated. There is a platinum electrode in each basin near the end of the capillary tube. By increasing the atmospheric pressure over the liquid in one basin, the water is pressed through the capillary tube; an e. m. f. is then observed between the two platinum electrodes. The sign of the e. m. f. depends upon the direction in which the water flows. The e. m. f. is proportional to the difference of the pressure at both ends of the capillary tube; it also depends upon the distance of the electrodes from the ends of the capillary tube.—*Bull. de l'Ac. des Sc. de Cracocie*, June; *Phys. Zeit.*, Dec. 8.

Permeability of Iron Under the Influence of the Oscillating Discharge from a Condenser.—MARCHANT.—A paper in which he gives photographs of sparks taken with the aid of a revolving mirror, from a coil of 5 millihenry self-induction and a Leyden jar of 0.06 microfarad, the difference of potential before discharge being 13.5 volts. The effect of the soft iron core upon the nature of the spark is well shown. The first half oscillation with the core in the coil is seen to be nearly twice as long as without it, and a series of oscillations follow it, gradually increasing in length.—*Nature*, Aug. 30; abstracted in *Science Abstracts*, Nov.

REFERENCES.

Electric Oscillations.—FLEMING.—An abstract of the third of his series of Cantor lectures on this subject. He gave a summary of Maxwell's theory and discussed some of its consequences as to the identity of the ratio between the absolute unity of the electrostatic and electromagnetic system, with the velocity of light; also the relation between dielectric constant and refractive index. He also discussed various other theories, especially that of Larmor.—Lond. *Elec. Eng., Elec.*, Dec. 14.

Roentgen Rays for Physicians.—ROLLINS.—The first part of an illustrated description of several instruments and apparatus for the production of Roentgen rays for the use of physicians in this country.—*Elec. Rev.*, Dec. 19.

Magnetization of Electro-Deposits.—MAURAIN.—An account of experiments made to compare the magnetization of a deposit of electrolytic iron produced from ammonium oxalate of iron in a magnetic field, with the magnetization of the same deposit exposed to the magnetic field after deposition. The results are shown in curves.—*Comptes Rendus*, Nov. 26; abstracted in Lond. *Elec.*, Dec. 14.

ELECTRO-CHEMISTRY AND BATTERIES.

Electric Bleaching.—OETTEL.—An illustrated article on the Haas and Oettel system of electric bleaching. As electrolyte, a sodium chloride solution of 4 to 6 degs. Baume is used; for the single negative end electrode, a lead plate; all other electrodes are of specially-prepared carbon; each of the many intermediate electrodes dividing the tank into numerous cells, acts as anode on one side and cathode on the other, in the two adjoining compartments respectively. A good circulation of the electrolyte is produced by making it flow from the first compartment over the first intermediate electrode into the next compartment, from there below the second intermediate electrode to the third compartment, and so on; from the last compartment it runs off as bleaching solution into a basin. Such an apparatus in 10 hours gives 3000 liter of lye with 3 grams of bleaching chlorine per liter therefore a total of 9 kilograms of chlorine, with 45 to 50 amperes at 110 volts; hence for the given chlorine concentration 7.5 to 8.3-hp hours are consumed per kilogram of bleaching chlorine. Recently it has become necessary to get strong bleaching lyes, containing 5 to 10 grams of bleaching chlorine per liter. It is impossible to accomplish this by running the lye at a lower speed through the apparatus, as the temperature rises too much. Kellner uses a more concentrated solution and runs the solution into a basin, where it is cooled down, and by means of a pump it is forced back into the apparatus; this process is repeated, until the bleaching solution has the required concentration. Haas and Oettel use an interesting device by which during the electrolysis the solution is in perpetual automatic circulation between the electrolytic bath and the cooling basin; they utilize for that purpose the hydrogen developed by electrolysis. The electrolyzer is placed into the cooling basin; in general the electrolyzer is arranged as described above, but its compartments are separated from one another; each compartment is in communication with the external cooling basin by a hole in the bottom and by an overflow gutter at the upper rim. As long as there is no electrolysis there is hydrostatic equilibrium between the solutions in the electrolyzer and the cooling basin; when, however, electrolysis is started, the solution in the electrolyzer contains hydrogen bubbles and has therefore a lower specific gravity than the solution outside; there is no longer a hydrostatic equilibrium, but the liquid tends to rise in the compartments of the electrolyzer and flows over through the gutters. He gives a result of a test made with an electrolyzer of 28 compartments, with 60 amperes at 115 volts. 840 liter of sodium chloride of 15 degs. Baume being used; after the first hour the solution contained 2.55 grams of bleaching chlorine per liter and 4.48-hp-hours are consumed per kilogram of chlorine; after the tenth hour the solution contained 14.31 grams of bleaching chlorine per liter and 8.11-hp-hours are then consumed per kilogram of chlorine. He shows that it is economical to use solutions of higher concentration. He compares his system with that of Kellner, in order to show that the latter is less economical.—*Zeit. fuer Elektrochemie*, Nov. 22.

Testing Storage Batteries.—A note stating that Gorski, while testing the "monobloc" storage battery with an auxiliary electrode of cadmium, has proven that the total e. m. f. of a storage battery does not enable one to draw a conclusion concerning the condition of charge of the single electrodes. In one case a storage battery, being discharged, showed 1.9 volts at the terminals, while the e. m. f. between cadmium and the positive polelectrode was 2.2 volts, that between cadmium and the negative polelectrode 0.3 volts, showing that the latter was nearly exhausted. In another case, when a battery was charged at 2.4 volts, the e. m. f. between cadmium and the positive

SWISS.

Journal Telegraphique.	*Jour. Telegraphique*.....Berne
Revue de L'Electricité.	*Rev. de L'Elec*.....Berne
Schweizerische Blaetter fuer Elektrotechnik.	*Schweis. Blaetter fuer Elek*.....Berne

AMERICAN.

American Electrician.	*Amer. Elec*.....New York
American Journal of Science.	*Am. Jour. of Sc*....New Haven, Conn.
Appleton's Popular Science Monthly.	*Appleton's Pop. Sc. Mo*....New York
American Machinist.	*Amer. Mach*.....New York
Bulletin of the University of Wisin.	*Bul. Univ. Wisc*.....Madison

Cassier's Magazine.	*Cassier's Mag*.....New York
Electrical Review.	*Elec. Rev*.....New York
Electricity.	*El'ty* .....New York
Engineering Magazine.	*Eng. Mag*.....New York
Engineering News.	*Eng. News*.....New York
Engineering and Mining Journal.	*Eng. and Min. Jour*.....New York
India Rubber World.	*Ind. Rub. World*.....New York
Journal of Electricity, Power and Gas.	*Jour. of El'ty*.....San Francisco
Journal of the Franklin Institute.	*Jour. Frank. Inst*.....Philadelphia
Journal of the Telegraph.	*Jour. Teleg*.....New York
Journal of the Association of Engineering Societies.	*Jour. Assn. Eng. Soc*.....Chicago
Journal of the Western Society of Engineers.	*Jour. West. Soc. Eng*.....Pittsburg

polelectrode was 2.45 volts, while that between cadmium and the negative polelectrode was 0.05 volts, showing that the latter was still at the start of the charge.—*Centralblatt. fuer accum. und Elem. kunde,* Dec. 1.

Calcium Carbide.—J. B. C. Kershaw.—The conclusion of his article. He describes briefly the three most efficient forms of carbide furnace: The furnace of the Deutsche Gold and Silver Scheide Anstalt, the Willson furnace used at Foyers, and the Gin and Leleux furnace used at Meran. He concludes that the highest yields have been obtained in furnaces working on the intermittent system, with movable box hearths, in which the carbide produced is allowed to cool. Where the cost of power is important, the intermittent system of furnace is to be preferred. Where power is cheap and manual labor costly, it may be better to adopt a continuous type of furnace, from which the carbide is tapped at intervals. With both types there appear to be possibilities of improvement in regard to the utilization of the carbon monoxide gas, which ought not to be allowed to burn away without any utilization of its heating power. Another direction in which greater efficiency and economy may be expected is in connection with the preparation of the raw materials; the idea that it is essential to have these finely ground and thoroughly mixed is now proved to be incorrect.—Lond. *Elec.,* Dec. 14.

Siemens & Halske Gold Process.—J. B. C. Kershaw.—A paper in which he says that the Siemens & Halske process for recovering the gold from the liquors obtained by the treatment of the crushed ore, or the tailings, with dilute potassium cyanide solution, is rapidly making headway, and its application to the solutions, resulting from a still more modern process for successfully leaching slimes with cyanide, is calculated to further extend the field of usefulness. The process has come to stay in South Afrca. It depends upon the deposition of the gold from very weak cyanide solutions by means of an electric current of feeble intensity. Iron is used for the anode, and thin sheets of lead as cathodes. The difficulty of extreme dilution was overcome by causing the electrolyte to pass between several hundred pairs of electrodes before issuing finally from the last of the depositing vats. No attempt is made to remove the whole of the gold from the cyanide solution, the continual return of the effluent to the leaching vats rendering a complete exhaustion of gold unnecessary. Some information is given about the actual South African plant and on the cost of operation. The process is, however, not yet perfect.—*Jour. of Elec.,* December.

Commercial Electrolysis of Water.—Buffa.—An article, giving information on the electrolysis of water, which is in commercial use in several cities. The apparatus are voltameters with iron electrodes; the bath is alkaline. The voltameter is placed in an iron basin containing the electrolyte and has the form of an iron box without a bottom; it is placed upon wooden strips on the bottom of the basin. Vertical diaphragms divide the voltameter into a number of partitions, open at the bottom, into which the anodes and cathodes are placed alternatively; those of each polarity are connected together like the teeth of a comb. Each of these partitions has a hole at the top and through these holes the oxygen and hydrogen pass to the gas basins. In the plant at Rome the electrolyte is a 14 per cent concentration of a sodium solution, or a 16.8 per cent concentration of a potassium solution. The temperature must not fall below 10 deg. C. The current density must not surpass 2 ampere per square decimeter. Some information is given on details of the plant in Rome. Several applications of hydrogen and oxygen, for different purposes, are briefly discussed.—*Bull. de l'Ass. des Ing. Elec., Inst. Elec. Montefiore;* abstracted in *L'Ind. Elec.,* Nov. 25.

Electrolytic Reduction of Difficultly Reducible Substances in Sulphuric Acid Solution.—Tafel.—An account of a special study of the behavior of caffeine "with a view to elaborating a method which would allow of the systematic regulation of the experimental conditions and afford a general method for the preparation of compounds by electrolytic reduction. The reduction of caffeine in sulphuric acid solution is only possible when the cathode consists of a material (lead or mercury) showing a high cathode potential. The disturbances often observed in reductions are found to be due to the contamination of the cathode by traces of foreign metals, and are best avoided by coating the surface of the electrode with lead sponge, electrolytically deposited. The reduction is hastened by a rise of temperature, but only to a slight extent. The current yield, within certain limits, is nearly proportional to the current. For equal concentrations of caffeine and equal currents per litre of liquid at the cathode ("current concentration") the current density has relatively little influence on the course of the reaction, the reduction increasing slightly as the current density diminishes. In apparatus of similar construction, but different size, the reaction follows the same lines, provided the initial concentration of the substance, the current concentration, and the relation between the surface of the cathode and the volume of the cathode liquid are the same in each case."—*Zeit. Phys. Chem.,* July 17; abstracted in *Science Abstracts,* November.

Gas Batteries.—Haber.—He argues that the oxidation potential of hydrogen peroxide, together with its reduction potential, represents the oxygen potential; this implies that for fixed values of the hydrogen concentration and the oxygen concentration there is only one stable value for the hydrogen peroxide. That value obtains at the oxygen electrode, and remains constant as long as that electrode operates in a reversible manner. But the concentration of the hydrogen peroxide does not affect the dynamics of processes in which the maximum work is yielded, and which can be reduced to the work of a battery of the form: metal, metallic ions, hydroxyl ions, oxygen electrode. When the processes are rapid, however, certain metastable conditions may occur, and it is to such conditions that he attributes the phenomena observed at a platinized platinum electrode dipping into hydrogen peroxide solution, as well as the catalysis of hydrogen peroxide by finely divided platinum.—*Phys. Zeit.,* Dec. 1; abstracted in Lond. *Elec.,* Dec. 14.

Electro-chemical Industry in France.—Guillet.—A review of the progress of the chemical industry in France. Regarding electrochemistry, the following information is given: Caustic soda is produced by two companies, using the Greishem and the Outhenin-Chalandre process, respectively, 2500 tons being produced yearly by the former process. Alkalies and bleaching powders are produced in an 8000-hp plant in Savoy. Another company produces potassium permanganate, ammonium persulphate, chlorates, and perchlorates; the second of these is obtained by electrolysis of ammonium sulphate, it is used in bleaching operations and in photography. The total French output of chlorate is estimated to be 3850 tons, of which total 3000 tons are produced by electrolysis. Perchlorate of ammonium is a new chemical, used in preparing mining explosives. The manufacture of phosphorus in the electric furnace is about to be introduced into France. Calcium carbide is made in eight factories, with an aggregate capacity of 14,400 horse-power.—*Genie Civil,* June 30, July 7, 14, 21, 28, Aug. 4; abstracted in *Science Abstracts,* Nov.

Electro-chemistry in 1899.—The first part of an article on progress of electro-chemistry in 1899. Brief descriptions are given of new inventions or improvements, mainly taken from patent specifications; sometimes critical remarks are added. Among others the following inventions are noticed: The Kossuth process of producing bromine by electrolysis of the waste lyes, obtained in the manufacture of chloride of potassium; the use by Moissan of copper, instead of platinum, in the electrolytic production of fluorine from hydrofluoric acid or fluorine salts by means of a U-tube; a new method, devised by Billandot & Company, for condensing the phosphorous vapors developed in the electric production of phosphorus; the Acheson process for making graphite in the electric furnace; Mach's alloy of aluminium and magnesium, which is easily worked with the file and similar tools; a Cowper-Coles method for producing vanadium by electrolysis from aqueous solutions.—*Elek. Anz.,* Dec. 9.

Units. Measurements and Instruments.

Magnetized Chronometer.—Cornu.—An account of experiments with a chronometer, which by accident had been brought near a large

Progressive Age.	*Prog. Age*.....New York
Proceedings of the Engineers' Club of Philadelphia.	*Proc. Eng. Club Phila*....Philadelphia
Proceedings of Engineers' Society of Western Pennsylvania.	*Proc. Eng. Soc. Pa*.....Pittsburg
Power.	*Power*.....New York
Rose Technic.	*Rose Tech*.....Terre Haute
Street Railway Journal.	*St. R'y Jour*.....New York
Street Railway Review.	*St. R'y Rev*.....Chicago
Scientific American.	*Sc. Amer*.....New York
Scientific American Supplement.	*Sc. Amer. Sup*.....New York
Science.	*Science*.....New York
Transactions of the American Institute of Electrical Engineers.	*Trans. Am. Inst. Elec. Eng.*New York

The Automobile.	*The Automobile*.....New York
The Physical Review.	*Phys. Rev*.....New York
Transactions of the American Society of Mechanical Engineers.	*Trans. Am. Soc. Mech. Eng.*New York
Technology Quarterly.	*Tech. Quart*.....Boston
Terrestrial Magnetism and Atmospheric Electricity.	*Terr. Magnetism*.....Baltimore
Telephone Magazine.	*Tel. Mag*.....Chicago
The Engineer.	*The Eng*.....Cleveland
The Polytechnic.	*Polytechnic*..... Troy
The School of Mines Quarterly.	*Sch. Mines Quart*.....New York
The Sibley Journal.	*Sibley Jour*.....Ithaca
Western Electrician.	*West. Elec*.....Chicago
Yale Scientific Monthly.	*Yale Sc. Mo*.....New Haven

dynamo. It was considerably influenced by the earth's magnetic force. there being a definite acceleration or retardation for each azimuth; the equations expressing this effect are similar to those representing the action of gravitation upon an imperfectly balanced wheel. The practical importance of these researches lies in their bearing upon ships' chronometers. The magnetism of their balance-wheels should be carefully determined, as well as the corrections necessary for various magnetic azimuths.—*Comptes Rendus,* Nov. 26; abstracted in Lond. *Elec.,* Dec. 14.

Frequency Meter.—A brief illustrated description of a frequency meter of Hartmann & Braun, which was exhibited at Paris, for measuring the frequency of any periodic current, either ordinary alternating current, or pulsating direct current, or the current from an induction coil. The instrument is independent of the wave form. It has the form of a voltmeter or ammeter, with a scale for frequencies between 80 and 115; there are 36 steel springs, tuned in the intervals of the whole numbers between 80 and 115. A broad needle can be turned around the scale by means of a button; on the axis of this needle there is an alternating current magnet system. The needle is turned around until it is opposite to the correct steel spring which then begins to give a loud tune.—*Elek. Anz.,* Dec. 9.

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Measuring Instruments.—ALIAMET.—The conclusion of his very long, illustrated paper on electric measuring instruments at the Paris Exposition. He concludes the description of voltmeters; discusses the measurement of resistance, resistance boxes, potentiometers, direct reading ohmmeters; deals brifly with condensers and inductances; describes wattmeters; several special instruments to be used with alternating currents, as phase meters, frequency meters, instruments for plotting the wave form; instruments for the study of the magnetic properties of iron, as permea meters and hysteresis meters; thermo-electric pyrometers for measuring temperatures.—*Bull. Soc. Int. des Elec.,* Sept.-Oct.

Localizing Faults.—An illustrated description of several methods of localizing faults in electric lines and cables, especially in difficult cases.—*Elek. Anz.,* Dec. 6.

Magnetometer Constant.—CHISTONI.—He determines the constant of a unifilar magnetometer by placing a deflecting magnet at each of two distances from the needle. He gives two formulas, the first being rigorously correct, the second simpler, but only approximate.—*Acad. Sci. Torino,* atti 35, 8a, 1900; abstracted in *Science Abstracts,* Nov.

Firing Mines.—An illustrated article on "Laying out mine fields in the Royal Navy," more especially on the use of the "depression range-finder."—Lond. *Elec. Rev.,* Dec. 14.

TELEGRAPHY, TELEPHONY AND SIGNALS.

Recorder Working on Composite Landline and Cable Circuits.—DAVIDSON.—A brief description of the application of Harwood's duplex arrangement of circuits composed of cables and landline, as shown in the adjoining diagram. In view of the extending use of the siphon recorder for landline work, cases may happen, where it would be useful. *B* and *C* are the terminal stations of the landline. "The signals from station *D,* received at *C* in the usual way, are transmitted direct to station *A*. Signals from *A* are similarly transmitted by *B* to station *D*. The landline recorders at *B* and *C* are permanently in circuit in order to give a record of what is passing through and also to show the state of the balance. If *B's* recorder is practically unaffected when *B* is sending to *D,* while the signals from *C* to *A* are of legible size, the same state of things will obtain at *A's* recorder and duplex working will be possible. The arrangement can be divided up for sectional working by introducing earths at *B* and *C* on the apex to apex lead. The principal source of disturbance is, of course, the variation of the insulation of the landline, but the recorders at *A* and *D* are so far away electrically that the landline balance must be out very considerably before the incoming signals are affected." The system has been worked successfully over a tropical landline subject to heavy varying leakage.—Lond. *Elec.,* Dec. 14.

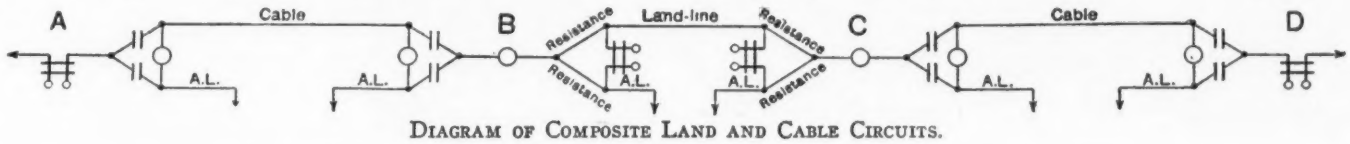
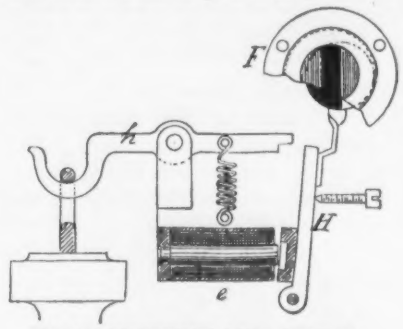


DIAGRAM OF COMPOSITE LAND AND CABLE CIRCUITS.

West System of Party Lines.—RUHMER.—In Berlin, in any house which has a telephone connected to the public telephone system, five other parties are also allowed to have telephones connected to the same line; while for the connection of the main telephone $45 per year is charged, for each of the other telephones the charge is only $3.75. The connections are sometimes made by the janitor as an intermediate operator; but there was a lack of punctuality and he could listen to



PARTY TELEPHONE LINE SYSTEM.

all calls. The West system, however, fulfills the following conditions: Eaeh telephone can call up the exchange without intermediate operator; at each telephone a signal always shows whether the line is busy or not; as long as one party is talking, it is impossible for any other party to use the telephone and to interfere; the exchange can call up any party without troubling the other parties. When a party takes the telephone from the hook, he is connected automatically with the exchange and the five other telephones of the same line are automatically arrested, which is accomplished by "arresting electromagnets" *e,* placed at each telephone, and shown in the adjoining figure; when *e* is excited, the lever *H* is attracted and the hook *h* is arrested; at the same time a signal becomes visible at *F,* showing that the line is busy. In order to enable the exchange to call up any party without troubling the other parties and to prevent any other party from trying to use the telephone at that time, an automatic switch is used, which can be placed at any point in the house and is connected with the telephones by local lines; its operation is described and illustrated, but is too complicated to be given here.—*Phys. Zeit.,* Dec. 8.

REFERENCES.

Railway Signals.—Abstracts of three papers, read before the Brit. Inst. Civ. Eng.: Szlumper, on "The Signalling on the Waterloo and City Railway;" also a "Note on Signalling Outlying Siding Connections;" Cottrell, on "Signalling on the Liverpool Overhead Railway."—Lond. *Elec.,* Dec. 14.

Type Printing Telegraph.—CONRADT.—A communication supplementing his article on an improvement of the efficiency of the Hughes apparatus by modifying the arrangement of the keys (Digest, Oct. 13).—*Elek. Zeit.,* Dec. 6.

Statistical.—The first part of a statistical article on telegraphy and telephony in France; also large statistical tables on telegraphy in 1899 in different countries all over the world (the United States not being included).—*Jour. Teleg.,* Nov. 25.

MISCELLANEOUS.

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Obituary.—An account of the life and work of the well-known metallurgist, C. Hoepfner, who died recently in Denver, Col. A number of his electro-metallurgical processes have been described in the Digest.—*Eng. & Min. Jour.,* Dec. 22.

Medical Electricity.—A paper, by Yvon, giving an account of experiments which show that the static electricity, in the form of "static baths," produces no physiological effects. Another paper, by Leduc, describing an oscillating rheostat for producing current waves.—*Archives d'El. Medicale,* June, July; abstracted in *Science Abstracts,* Nov.

New Books.

BOOKS RECEIVED.

THE LEAD STORAGE BATTERY. Its History, Theory, Construction and Use. By Desmond C. Fitzgerald. London: Biggs & Company. 383 pages, illustrated.

THE THEORY OF COMMUTATION. By C. C. Hawkins. London: George Tucker. 81 Pages, 24 illustrations. Price, 2 shillings, sixpence.

The "C & C Series-Parallel" System of Motor Control.

By Geo. Fowler.

The application of direct geared motors to large newspaper printing presses offers one of the most interesting problems met with in electrical engineering work. The requirements are certainly most severe, and yet the system herein described performs its work with the ease and satisfaction which is generally credited to the simplest application of the direct current electric motor.

The plant in question is the first of its kind installed, and the writer believes that a description of it at this time will prove interesting because it contains a great many new and unique features.

With an increase in circulation it became necessary for the *Evening Telegraph* to add to the capacity of its press room. When the question of motive power presented itself, inquiry was made into the different systems, and it was finally decided to use direct connected motors and a system of electrical control.

The press equipment consists of six quadruple web perfecting presses, of which four have been installed, built by R. Hoe & Company, of New York. Each press has a capacity of 48,000 eight-page papers per hour when driven at its maximum speed. They represent the latest and most improved form of printing machine placed on the American or foreign markets.

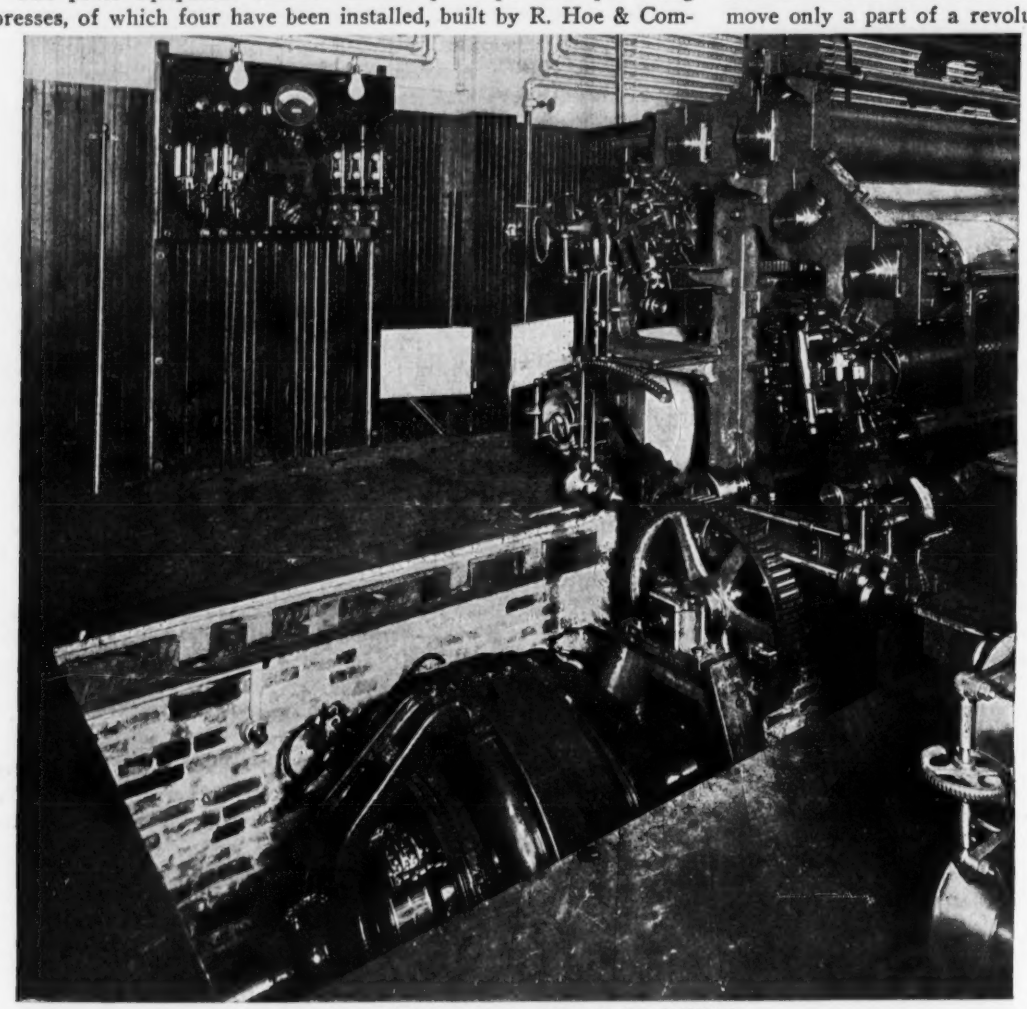


FIG. I.—SERIES-PARALLEL SYSTEM OF CONTROL.

The system used to control and operate these presses is that recently designed, patented and built by the C & C Electric Company, of New York, and known as the "series-parallel" method of control. Each press is operated by a 50-hp 250-volt 6-pole double commutator compound-wound motor directly geared to the main driving shaft of the press, the maximum motor speed being 400 r. p. m. (See Fig. 2.) In construction the motor consists of a single field frame of soft cast steel with inwardly propecting poles, the armature being of the slotted type and having two independent sets of windings. Each winding is thoroughly insulated from the other and connected to its own commutator. The gearing ratio is to 2 to 1, therefore the press shaft and also the impression cylinders run at 200 r. p. m.

In addition to the motor there is a controller located beneath the press room floor, the controlling arm of which is connected to a lever working through a notched quadrant bolted to a convenient part of the press.

Two automatic switches (see Fig. 4) are also located beneath the floor and fastened to the wall of the pit. An independent switchboard with ammeter, main switch, circuit breakers, etc., completes the equipment.

Practically two distinct speeds are required of the motor. First a very slow speed, not exceeding 20 r. p. m. (10 r. p. m. of the impression cylinders) to "make ready," lead in the sheet, etc., and the normal running speed, which, as before stated, is 400 revolutions of the motor. Of course all speeds up to and in between these two required speeds must be obtained by gradual increase and without spasmodic jumps. It is very common with pressmen, unless there is occasion for a "rush edition," to run the presses a little below the maximum, and in a great many cases this speed does not exceed 190 r. p. m. (380 r. p. m. of the motor). Another operation which the motor is called upon to perform is "inching." This is a partial movement of the press cylinders to get them in a certain desired position, sometimes to place thereon the "forms" containing the printed matter, and for various other reasons. To do this the motor must start and move only a part of a revolution, or at most one or two, and stop again. The starting and stopping must be accomplished without the slightest jar or jump in the speed. Should this occur it is quite likely the sheet would be broken and a great deal of valuable time lost.

This system performs each and every operation to entire satisfaction, and solely through the use of a small controlling lever. The slow speeds, "inching," etc., are obtained with the two armature windings in series with each other, and in series with the series field and also some resistance. The high speeds are obtained with the armature winding in parallel, the series coils on the fields being short circuited and without external resistance, and the highest speeds with slightly weakened shunt field. External armature resistance is used only for intermittent graduations of the speed and for starting.

The controller referred to above (see Fig. 5) consists of numerous contacts mounted on a marbleized slate slab and connected at suitable points to the armature resistance; also contact rings for conveying the current to the shunt fields and a few smaller contacts to operate the automatic switches.

These switches are described below. The controller arm carries the brush which gives the speed changes by varying the resistance, and it also carries a brass shoe which short circuits the contacts connected to the automatic switches, operating them at the proper time. Two other shoes are used, one to complete the armature circuit and the other the field.

The automatic switches were specially designed for this service. Each switch consists of two solenoids wound with fine wire, iron-clad in construction, mounted on one side of a slate. The leads from these solenoids are connected to the automatic switch contacts on the controller and are operated by taking a small amount of current directly from the 250-volt circuit. The solenoids work a couple of plungers which are keyed to a shaft extending to the other side of the slate and carrying two blades that work in and out of eight switch jaws. A reference to Fig. 4 will give a more accurate idea of the construction. The switch jaws are connected to the main lines of the two armature windings and controller. There are two switches, one called the "off and on," the other the "series-parallel." The "off and on" switch operates first to one side, then to the other, each

time the press is started and stopped; that is, it opens and closes the main circuit of the motor. The "series-parallel" switch operates only when the windings are changed from series to parallel, or vice versa; or, in other words, when the controller arm is moved to run the motor at high speed, this switch opens the armature circuit and closes it again on the opposite side with the windings in parallel.

The function of these switches is to prevent arcing at the controller contacts by making and breaking the circuit at the switches instead of the controller, and also at the time of changing the windings from series to parallel. It can readily be seen that by this means of throwing the brunt of the work on the switches the life of the controller contacts is very materially increased. In fact, there is not the least sign of arcing on the controller. The switches are instantaneous, it taking only a fraction of a second for them to throw from one side to the other, and without arcing.

Let us now trace the path the current takes when the motor is running. The main switch on the switchboard is closed first; this gives the full strength shunt field of the motor.

This switch is left in circuit from the beginning of run until completed, and when closed the current is conveyed as far as the automatic switch terminals. The first move of the lever (see Fig. 3) by the pressman short circuits two of the switch contacts on the controller, throwing the "off and on" switch to the "on" side, and no matter in what position the "series-parallel" switch may be, it is immediately thrown to the side connecting the armatures in series. The circuit is now closed and the current enters at one terminal of the "off and on" switch, thence to the controller through some starting resistance, through the series winding on the fields, through the "series-parallel" switch, through the two windings of the armature in series, and back into the line. This gives the slow speed necessary for "leading in the sheet," etc. The next few moves of the lever gradually cut out the armature resistance. When this is all out one-half of the series windings on the field are short circuited, and with the next movement of the lever the other half of the series are short circuited. This is accomplished by means of a small switch attached to the controller face and operated by a stud on the controller arm. The motor is now running as a plain shunt machine, with the armature windings in series, and without external resistance. This gives an intermediate speed, about 175 r. p. m. of the motor. Now the next move of the lever short circuits the two automatic switch contacts which are connected to one of the coils on the "series-parallel" switch and throws this switch to the parallel side, first opening the circuit where the windings were in series, and closing on the opposite side with them in parallel. The throwing of the switch can never be noticed on the press, for it is done so quickly and the speed kept the same (175 r. p. m.) as it was just before the switch was thrown over by the introduction of certain resistance at that instant. The next few moves of the lever gradually cut out this armature resistance until it is all eliminated and the motor is then running as a plain shunt machine with each armature winding directly connected across the current supply. At this point the speed is about 350 r. p. m. The final movements of the lever interpose some resistance in the shunt field, which increases the motor speed in gradual steps to 400 r. p. m. The devices furnished for stopping the press quickly are known as "floor stops," or emergency switches. In construction these are something like a floor push-button, only much larger and heavier. Four of these are placed in the floor, located at convenient intervals, and should it be desired to stop the press the placing of the foot on one of these stops immediately shuts off the current and stops the motor quickly. This push is so arranged that when the plunger is depressed it short circuits the two contacts that are connected to one coil of the "off and on" switch, which throws this switch to the "off" side, thereby opening the main circuit. The press cannot be again

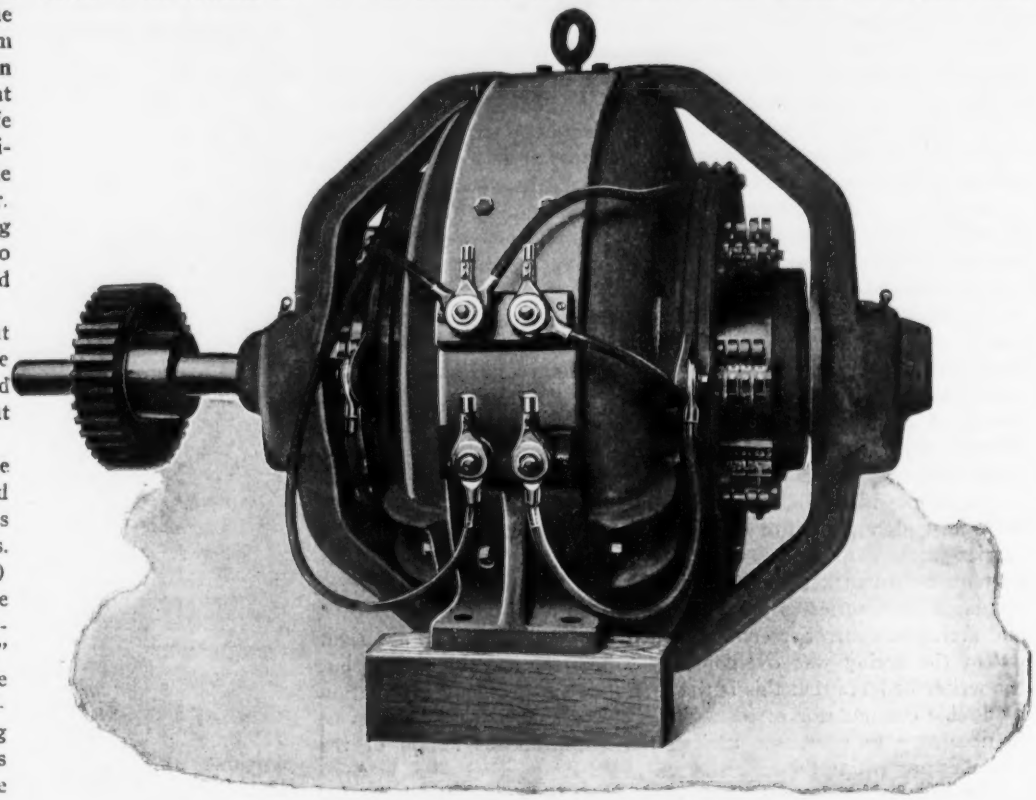


FIG. 2.—50-HP DOUBLE COMMUTATOR MOTOR.

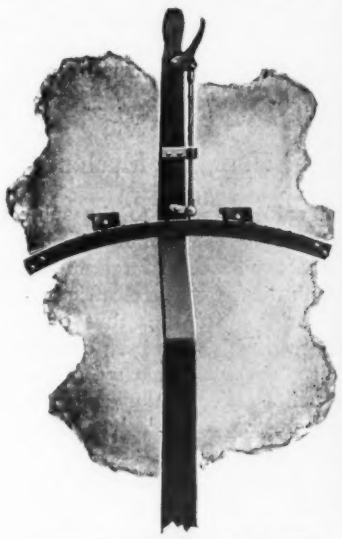


FIG. 3.—CONTROLLING LEVER.

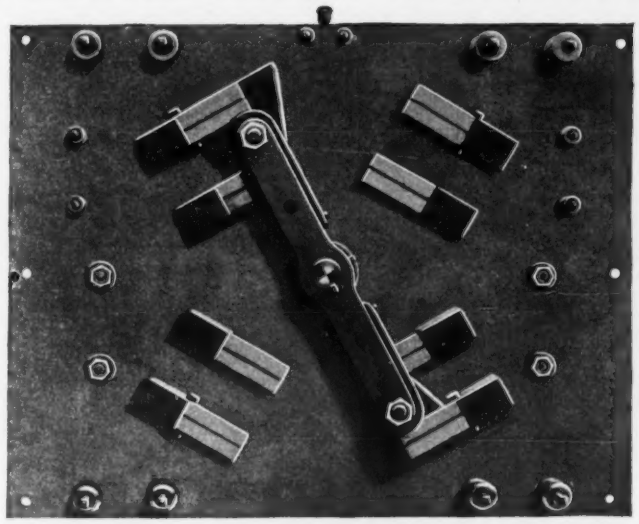


FIG. 4.—AUTOMATIC SWITCH.

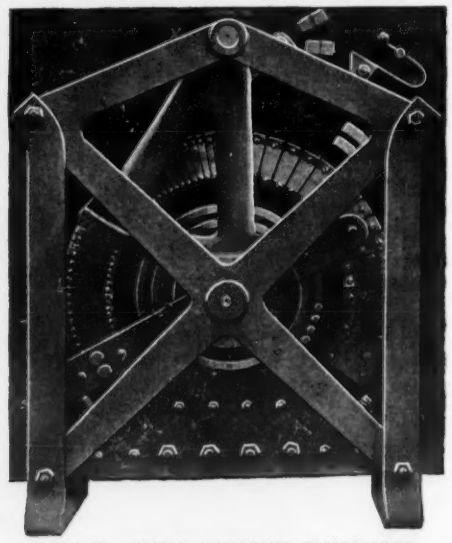


FIG. 5.—SERIES-PARALLEL CONTROLLER.

started until the lever is moved back to the starting position where the armature windings are again thrown into series and the series winding inserted with the proper starting resistance. It is an impossibility to start the motor improperly with the connections and devices in improper combination or to damage the electrical equipment or press as all combinations of connections are automatically made by the solenoid switches and controller.

This system of course contains some particular advantages, and among them may be mentioned the following:

First. By the use of the two separate windings on the armature which are used in series and in parallel, the starting torque with them in series is extremely great, but the current required to develop this torque is surprisingly small. From actual tests it has been shown that about one-third the current required to run the press at its highest speed is sufficient to start. A motor with only one winding and commutator with ordinary rheostatic control would be unsuitable for this class of work for the reason that to develop the necessary starting torque the current required would be far in excess of that necessary to run at normal speed.

Second. The flexibility of the controlling device is at once apparent, as all speed changes and different combinations are obtained through the movement of but one lever by the pressman, and for this reason accidents are less likely to occur. The automatic switches also serve as a safeguard, for, as described above, when the switch is thrown off by the "floor push" it is impossible to start again until the lever is brought to the starting position.

One of the main difficulties heretofore encountered by manufacturers in applying shunt or compound wound motors governed by the "series-parallel" method to stationary work where speed was an important consideration was the question of changing the armature windings from series to parallel without too much increase in speed and arcing at controller contacts when this was done. To a certain extent the arcing was overcome by using magnetic blow-outs, but the writer believes that this is the first entirely successful installation of double commutator motors. With this system no blowing device is necessary to overcome arcing, the instantaneous action of the switches preventing this.

The current for running these equipments is taken from the mains of the Edison Company, which are connected to one set of bus-bars on a special switchboard located at one end of the press room. This switchboard is equipped with two independent sets of bus-bars and a double pole throw switch for each press motor. To guard against possible break downs, and as time is such an important factor in a newspaper office, the other set of bus bars is connected to a pair of mains running to the switchboard in the engine room. Here they are properly connected to two 125-volt generators wired on the three-wire system to get the 250 volts. All connections are made to a marble switchboard containing instruments and switches of the latest type.

It seems to the writer that there is an extremely promising field for the further introduction of this system, and it is not limited to printing press work alone. In fact, to drive any piece of machinery where wide variations of speed are required, the double commutator method is one of the most advantageous and economical.

The *Evening Telegraph* plant has now been in constant operation, day and night, for nearly a year, and has demonstrated beyond a doubt the success of this system. Mr. William Meyers is in charge as chief engineer, assisted by Mr. Jacob Barger, while Mr. Harry Chappel is in charge of the press room, all of whom are well posted upon, and, I believe, strong advocates of the system.

It might be here stated that notwithstanding the fact that the equipments installed by the C & C Electric Company for the *Telegraph* were the first they installed, they have worked admirably from the first, and but very few minor adjustments and changes were necessary to bring the system to the point of perfection it has now reached. I understand that the company has already furnished and is now building quite a number of other similar equipments.

Automatic Elevator Motor Controller.

The illustration herewith shows the automatic elevator controller manufactured by the Three Rivers Electric Company, Three Rivers, Mich. This controller is designed for single belt-reversing freight and passenger elevator motors and consists of a reversing switch, rheostat and automatic cutout or current diverter combined in one piece of mechanism. No magnets whatever are used. The starting and stopping of the motor is done by a cable operated from the platform which transmits a positive movement that closes the switch to start the motor and automatically cuts out the rheostat. The reversing or controlling switch is placed on top of the controller and consists of two series of quick-throw switches of four blades each, mounted on a slate base with the operating shaft between them. On the end of each switch blade is a carbon brake tip for taking the spark on opening the circuit and protect the copper contacts from burning. The current diverter or cut-out for regulating the flow of current through the armature when starting is placed on the side of the controller and has twenty-one contact blocks. These contact blocks are mounted on a slate base, with a corresponding number of binding

AUTOMATIC ELEVATOR CONTROLLER.

blocks on the back for making connection to the rheostat. Pivoted to the iron frame on which the diverter is supported, and provided with slide pieces for making contact with it, is a swinging arm with strap connection to a cam wheel on the operating shaft of the reversing switch and a dash-pot below with suitable connection to the plunger to regulate the speed of starting.

The rheostat is of the company's standard open coil type made up of iron wire mounted on iron frames with plenty of ventilation on all sides. Ample capacity is provided for all current-carrying parts, and nothing combustible is used about it.

The Development of Centrifugal Pumping Machinery.

Electrical engineers who have not paid attention to the subject are surprised when they learn the extent to which centrifugal pumping machinery has been developed and introduced of recent years. Yet this work has been done largely with the aid of the electric motor and there seems to be no limit to the opportunities thus offered wherever current is obtainable. A concern which has been conspicuous in this field of work, the Lawrence Machine Company, of Lawrence, Mass., has already a list of such installations growing with great rapidity and presenting many interesting and remarkable features of design, utility and economy.

An interesting outfit is one that it is now building at its shops, consisting of a 30-in. centrifugal pump of its improved double-suction type, which has a capacity of 5000 tons of sea water per hour against a head of 25 ft. 9 ins. This 30-in. pump will be directly connected to an electric motor of 275 horse-power, direct current 220 volts. The outfit was sold through Mr. E. M. Sutliff, resident engineer of the Flint, Eddy & American Trading Company, for the Kawasaki dry dock of Kobe, Japan, and is the first plant of the kind ever installed in the far East. The guarantees on this outfit are of the most rigid character, and the contract was awarded to this country despite the fact that there were several European bidders, although only one other concern ventured to bid on an electrically driven apparatus.

The centrifugal pump has many advantages for moderate lifts, say up to 90 ft., and, again, can be erected with the greatest ease.

It works with a smooth, rotary motion, without valves, eccentrics, etc., and it is stated to be a recognized fact that it will discharge a quantity of water greater in proportion to the power expended than any other pump. It is very economical in use, simple in operation and of very great durability. It discharges a continuous

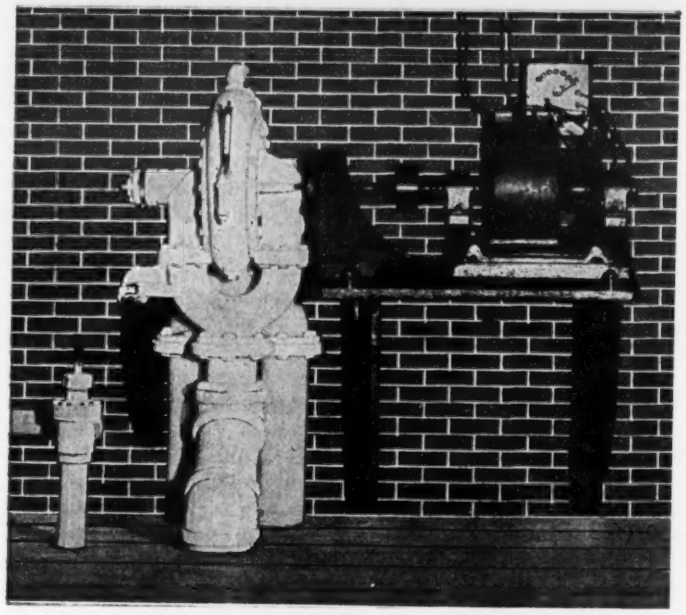


FIG. I.—CENTRIFUGAL PUMP.

and steady stream without air chambers. Its cost, measured by the quantity of water discharged, is greatly below that of other types, it is said. It is hardly affected by sand, mud or other foreign matter in the water. It will admit, in the larger sizes, the passage of solid bodies 6 ins. in diameter, and the smaller sizes in proportion, without injury. It will pump hot or cold liquids equally well. Moreover, it requires but a very light and inexpensive foundation, having no vibration or oscillation in its working.

A notable feature of the Lawrence improved double-suction pump is the branching of the suction pipe so that the fluid being pumped enters the disk chamber at each side, at and directly opposite the centre of the revolving disk, forming a balanced suction, and entirely dispensing with the end thrust on shafts, largely reducing the wear and loss by friction that would be likely otherwise to occur. The concern is particularly proud of its ability to turn out high-grade electrically driven pumping machinery, and its trade literature embraces many illustrations of the smaller types. These pumps are used for all purposes, such as water supply work, irrigation and drainage of land, emptying cofferdams and dry docks, and in all places where a large body of water is to be elevated to a moderate height quickly and cheaply and efficiently.

A very interesting outfit is that which is now being installed for the Edison Electric Illuminating Company, Brooklyn, consisting of four solid bronze pumps arranged for direct connection to electric motors. Each pump will be driven by a 20-hp motor and will be capable of delivering 3500 gallons of water per minute when running at 600 r. p. m. These pumps have a guaranteed efficiency of between 50 and 60 per cent, and a more practical pumping outfit could not be imagined. This local lighting company now has in operation seven Lawrence improved double-suction pumps, each electrically driven.

For the circulation of brine in connection with ice-making machinery, a special pump, built for this purpose, is coming into greater prominence daily, and it has now equipped a half dozen prominent plants with pumps of this description, all electrically driven. Fig. 1 shows a plant of this description installed for the Brooklyn Hygienic Ice Company. The pump mechanism is seen coated with ice.

Another very interesting installation is shown in Fig. 2, that of two pumps, each with a capacity of 3000 gallons per minute, elevated 40 ft. high, direct connected to General Electric motors for the Cataract Construction Company of Niagara Falls, N. Y.

For house service work, such as draining cellars, working in connection with lump pits, etc., a class of electrically driven centrifugal pumps are specially made. They occupy but very little space, are low in first cost, very cheaply operated, are automatic in their action, require little or no attention and can be operated by any one. In New York City alone there are dozens of these outfits, and it is said that the first complaint is still to be received. At the Passaic Print Works, Passaic, N. J., there are in operation six 8-in. pumps, directly connected with Westinghouse electric motors. These pumps are operating in connection with the filtration plant installed by the New York Continental Jewell Filtration Company and are of entirely special design, the method being that of utilizing high speed motors, back-geared to slow-speed pumps, rendered practically noiseless by the use of rawhide pinions. This greatly reduces the first cost of the motors. We are indebted to Mr. H. E. Maxfield, the manager of the New York office of the Lawrence Company, for the privilege of inspecting a variety and data of plans for electrical work with centrifugal pumps of a most interesting and striking character, going far beyond any of that which has been referred to in the brief notes above.

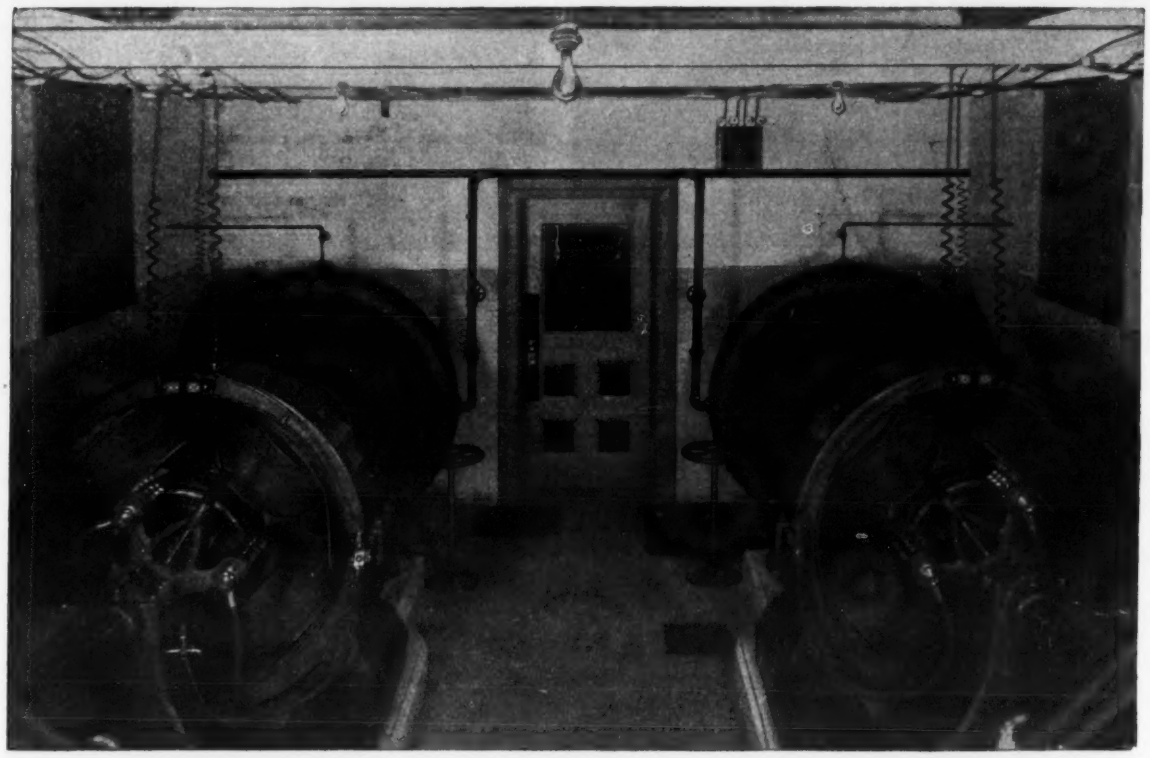


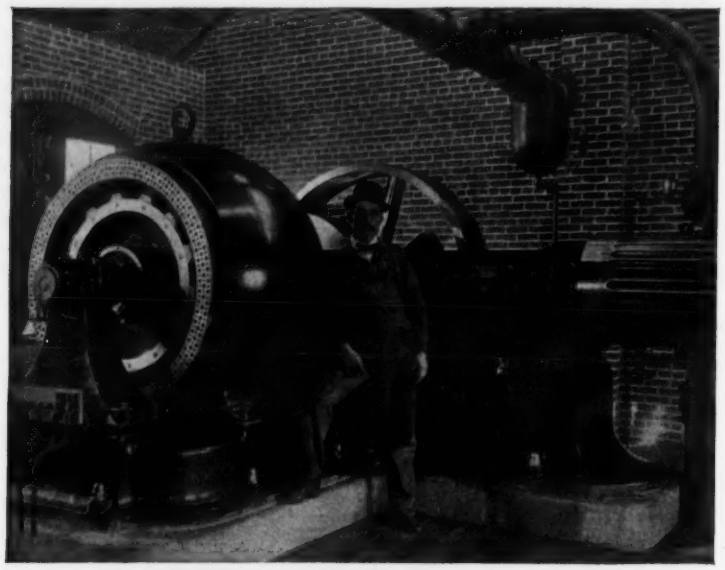
FIG. 2.—CENTRIFUGAL PUMP AT NIAGARA FALLS.

Electric Light Plant at Urbana, Ill.

The plant of the Urbana Electric Light, Heat & Power Company, Urbana, Ill., attracts no little attention on account of its electrical equipment and the application of the same. The present capacity of this plant is 215 kilowatts, of which 180 kilowatts is alternating and 35 kilowatts direct-current. There is, however, boiler capacity for some 300 kilowatts, and the addition of one 120-kw alternator is contemplated in the near future.

Alternators and switchboard were furnished by the Warren Electric Manufacturing Company of Sandusky, Ohio, the alternators being of the well-known Warren inductor type, and of 120-kw and 60-kw capacity, 60 cycle, direct-connected to 16x16 ins. and 13x12 ins. Ideal engines respectively, running at a speed of 257 r. p. m. One of the interesting features of the alternators, besides being direct connected, is the voltage at which they are run, both being designed for two voltages, viz., 220 and 2200 volts, the type and construction of the Warren alternator making such an arrangement possible; the capacity at each voltage is one-half of the full capacity of the alternators.

The idea of installing two voltage alternators was created by the situation of the plant, it being near the center of distribution of the commercial incandescent light service. Running this on a 220-volt, three-wire system it was possible at a very small investment in line copper to dispense with the use of transformers, and still be enabled to get high voltage distribution of arcs and distant incandescent light and power. The 220-volt system supplies four circuits of Manhattan enclosed series arcs for street lighting, as well as circuits for long-



URBANA, ILL., ELECTRIC LIGHT PLANT.

distant distribution of power and light. The 60-kw alternator takes care of the day load, and part of the evening load up to about 6 o'clock P. M., when the 120-kw alternator is synchronized and thrown in parallel with the 60-kw machine, and the load of the latter transferred over to the large machine. Later, during the night, the load is transferred back to the small alternator in a similar manner. There being two machines of two voltages of distinctly separate service, the parallel running and transferring of the load is accomplished by synchronizing each voltage separately. Accordingly, at times the 220 volt sides of the two alternators might be working in parallel, while the 2200 volt sides may be either idle or working on entirely different circuits and loads, or vice versa. This flexibility of control is very handy as well as very useful in the proper operation of the plant, from both a practical and a commercial point of view.

The 35-kw direct-current generator (a Triumph 500-volt machine) is driven off the flywheel of the smaller engine and is used for power service of such a nature that alternating curent would be less feasible. Some data on the Warren alternators might be of interest. The weight of the 120-kw alternator is, complete with rotor and shaft, 19,000 lbs., and the weight of the 60 kilowatt is 13,000 lbs. The outside diameters of the frames are 62 and 59½ ins., respectively, and the widths 32½ and 22½ ins. The rotor weights are 7000 lbs. and 37000 lbs., respectively, and they have a diameter of 42⅜ ins. and are provided with 14 teeth, which at a speed of 257 r. p. m. will give a frequency of 7196 alternations per minute, or about 60 cycles per second. The entire weight of copper on the 120-kw alternator is 835 lbs. and on the 60 kilowatt is 610 lbs. The exciters are compound wound, four-pole dynamos, each of ample capacity to take care of both alternators in case of emergency.

The switchboard, also furnished by the Warren Electric Manufacturing Company, is quite elaborate, consisting of four marble slabs, 66x44 ins. wide. Each of the two alternator boards is provided with one set of instruments for each voltage, as well as lightning arresters, main switches, fuse blocks, and exciter rheostats. One of the marble slabs is entirely used for distributing purposes, and besides the circuit switches is provided with synchronizers and equalizing switches. The fourth slab is used partly for the 500-volt direct-current service, but is also provided with ammeters for each individual arc circuit, as well as a recording voltmeter and a recording steam gauge.

This plant is modern in every detail, being supplied with the latest and most efficient apparatus securable, and neither money nor labor has been spared to make it, from the outset, one of the most profitable.

Electrical Development In and Around Pittsburg in 1900.

The electrical operations in that large industrial district, of which Pittsburg is the center, have been unusually active during the last year. The Westinghouse Electric & Manufacturing Company, of course, owing to its position in the electrical manufacturing interests, takes the lead. The company has made many very extensive additions to its immense factory at East Pittsburg. The old machine shop building was enlarged by the erection of extensions at each end, which makes the total length of this structure a quarter of a mile. Similar additions were made to the warehouse and the other buildings, while the company also completed its office building, which is seven stories high. The number of employees has been greatly increased and the company has now 6500 operatives on its pay rolls.

The Standard Underground Cable Company, another Pittsburg concern, during the year completed two new factories, one at Perth Amboy, N. J., and another at Oakland, Cal., in addition to the plant of the company in Pittsburg. By the addition of these facilities, the Standard people have become enabled to add considerably to their output of cable and underground wire and the number of their employees has been doubled during the year.

The Allegheny County Light Company, which practically controls the electric lighting systems in operation in Pittsburg and Allegheny, changed ownership during the year. While it was formerly one of the companies belonging to the Westinghouse interests, it is now an auxiliary concern of the Philadelphia company, which was purchased from Mr. Westinghouse by a syndicate of local capitalists. The Allegheny County Light Company has increased its capacity to a large extent, owing to the natural growth of the territory. Several large light generators, as well as power generators, were added to the main power house and others were also added to the sub-stations at Glenwood and in the East End. The company now operates about 75,000 incandescent lights and 2500 arc lights, while it also furnishes upwards of 1000 ehp for the operation of elevators and small manufacturing plants.

A similar operation took place with all the electric railways around Pittsburg, for which the negotiations are, however, still pending. It is now an assured fact that the Union Traction Company of Pittsburg will include all of the local street railways, except the Birmingham Traction Company, and this new organization will form one of the largest street railway corporations in the country, operating close upon 1500 cars and about 750 miles of track. The final formalities are now being completed, and when the deal is concluded there will no doubt be a number of changes in the operation, in the rolling stock equipment, as well as in the power houses, now operated severally. The companies taken into this combination are the Consolidated Traction Company, the Monongahela Traction Company, the United Traction Company, the West End Traction Company and the Suburban Traction Company, with their numerous allied lines and branches.

The practice of transmitting power electrically and utilizing it in the operation of machinery has grown in favor among the larger industrial establishments of the district. The Westinghouse companies and the Carnegie works, where the practice was first adopted, are constantly adding to their power equipment. The Carnegie Company uses several thousand horse-power in its Homestead plant alone

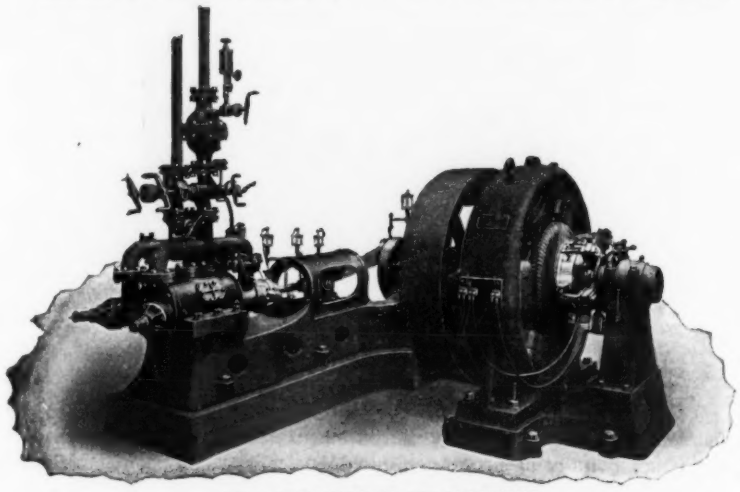
to operate cranes, mills and rolls. The National Tube Works at McKeesport, the Pennsylvania Tube Works, the H. K. Porter Locomotive Works, the Westinghouse Air Brake Works, the Westinghouse Machine Works, the Pittsburg Plate Glass Works, and the American Plate Glass Works are all large users of electric power, and they operate their own plants for generating electricity.

The automobile has also made its advent in this city during the last year. One company operates 10 and lets them out to private parties, while the department stores and some of the newspapers operate their own.

The year 1900 has witnessed the establishment of a new telephone company in the cities of Pittsburg and Allegheny, which has now some 2500 subscribers on its exchange list. This is the Pittsburg & Allegheny Telephone Company.

Triumph Direct-Connected Ice Machine.

The accompanying cut illustrates a Triumph motor direct-connected to an ice machine manufactured and installed by the Triumph Electric Company in the new office building of the Union Trust Building, Cincinnati, Ohio. The motor is of 25 horse-power and runs at 75 r. p. m. To secure this slow speed, the frame of a 60-kw direct-current generator was used in its construction. All resistance is cut out of the armature and fields, by using the field resistance in the shunt circuit. The motor is compound-wound so as to avoid taking excessive current while the compressor is passing the compression points at each end, the ice machine being double-acting. The machine is furnishing 350 gallons of filtered ice water at 38 degs. F. per



DIRECT-CONNECTED ICE MACHINE.

hour. There are also two triplex pumps driven by slow speed-belted motors of 600 r. p. m. These pumps will be used, one for circulating the brine, the other for pumping the ice water throughout the seventeen stories of the building.

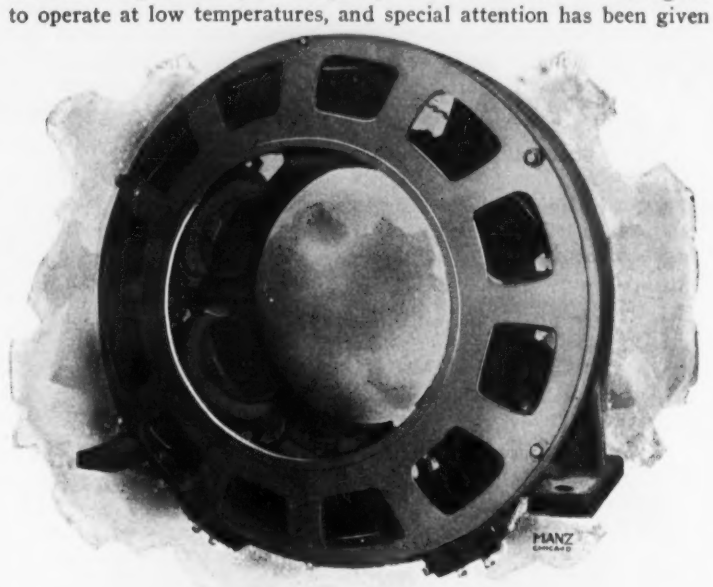
The main feature of this entire system is that any section can be cut out and repaired without shutting down the machine or stopping the work.

Improved Iron-clad Dynamos.

Electrical apparatus has reached a high stage of perfection, admitting of improvements chiefly in the details of its construction, and particularly in mechanical features. The demand of the consumer is for not only the most efficient electrical machine, but one whose operation is the most simple and which will withstand the most severe range and which shall be protected from external injury in every way possible.

Were it not for the great bulk and the necessarily greater expense entailed in the adoption of an entirely iron-clad line of dynamos, in large sizes, that design of machine might recommend itself even more strongly than it does to the general trade conditions. The two conditions noted, however, render such a wholesale adoption impracticable, and as a compromise, the semi-enclosed machine is to-day advocated by many as the best protected and the most economical machine for ordinary usages.

The accompanying illustration shows the design of the magnet frame of the semi-enclosed direct-connected line of machinery which has thus been recently placed on the market by the Commercial Electric Company of Indianapolis, Ind., and is made in all standard sizes from 25-kw to 150-kw capacity. These machines are designed to operate at low temperatures, and special attention has been given



MAGNET FRAME OF DYNAMO.

to securing high efficiencies at light as well as full loads. The details of the armature are in keeping with the demands of advanced engineering practices. Descriptive matter and illustrations will be furnished on application to the manufacturers.

Insulators for High Potential Transmission.

At a time when the development of power transmission is being carried on so rapidly, it is interesting to note the gradual evolution of the high potential insulator. In this article are illustrated two sizes of the "Victor" type of insulators manufactured by Fred M. Locke, of Victor, N. Y., who has done much to make possible the transmission of electrical energy at extremely high voltages. One cut represents a No. 304 "Victor" insulator, adapted to 40,000 volts, and another is a No. 316 "Victor" insulator for 60,000 volts. The same type includes insulation for any voltage down to 7000 volts. These insulators are made in brown or white, and every insulator is tested to twice its normal line capacity before leaving the factory, which insures perfect insulators for erection and minimizes the possibility of breakdown after the line is placed in operation.

The No. 316 has been adopted by the Standard Electric Company of California and by the Bay Counties Power Company to carry 60,000

FIG. I.—INSULATOR FOR 40,000 VOLTS.

volts line pressure, the total length of line aggregating 400 miles. In connection with the transmission of the Bay Counties Power Company, a nice problem has been presented in carrying the high voltage cable across the Strait of Carquinez, a distance of about 4700 ft. To meet the excessive strain of the cable, which is 19-strand steel, ⅞-in. diameter at this point, and to give the necessary insulating qualities,

there have been designed by Mr. Locke immense porcelain supporting and strain insulators. The supporting insulators are, in turn, supported by structural steel towers on both sides of the strait. An illustration of this supporting insulator is also shown here. This is 11 ins. high, 18 ins. in diameter and weighs 45 lbs. The strain insulator

FIG. 2.—INSULATOR FOR 60,000 VOLTS.

is 11½ ins. in diameter and weighs 32 lbs., surrounding the cable for a distance of 24 ins., and will be required to withstand a strain of 12 tons. There are to be four cables placed "staggering" so that they cannot approach one another within 25 ft. This span, which is the longest on any power transmission line in the world, is truly a remarkable piece of engineering, taking into consideration its great length, the weight of the cable and the high voltage, and is characteristic of the heroic means employed in developing power resources to-day in America.

FIG. 3.—SUPPORTING INSULATOR.

Production of Copper Coated Carbons.

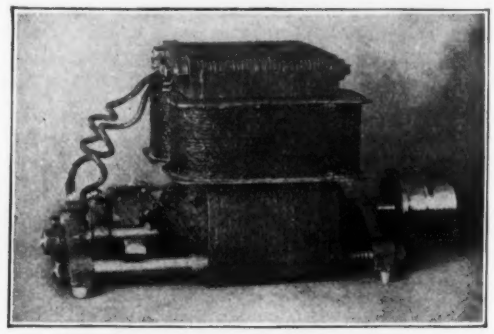
The new machine for automatically and continuously plating carbons, having a capacity of 120,000 carbons per day, installed last fall by the United States Carbon Company, of Cleveland, Ohio, in order to meet the constantly growing demand by this new company for copper-coated carbons, is one of the most ingenious pieces of mechanism employed in the electrical industry. The principle of the machine is simplicity itself. The carbons to be plated are deposited in large quantities in a hopper from which they are taken by a revolving drum and automatically fed to 3000 individual holders, carried on a continuous chain belt. The holders, in circuit with the electrical current, carry the carbons for a distance of 175 ft, through 14 plating tanks, being taken from one tank to the next over large idler wheels.

After passing through the plating tanks, the carbons pass through three tanks containing hot water, for boiling out the copper salts and fixing the color of the copper coating. The endless belt carrying the carbons then returns over the head, through the drying chambers, and after registering on the counter the carbons are automatically discharged from the holders on to a conveyor which carries them for a distance of 50 ft. to the packing room, located in one of the large buildings recently added.

Among the electrically operated, labor-saving devices, such as acid pumps, syphons, etc., used in connection with the machine, is a small double trolley motor car, for lifting and moving any one of the large plating tanks when it is necessary to clean it. This car is notable for the extreme compactness and simplicity of its design, using but one 10-hp ironclad motor for propulsion forward or back, lifting and lowering the tanks and the various operations required.

Franklin Dynamo or Motor.

The little machine illustrated herewith is designed for amateur construction. The Franklin Model Shop, Parsell & Weed, 129 West Thirty-first Street, New York, supplies all of the parts ready for winding and assembling by the amateur. The machine may be used either as a dynamo or a motor. When run as a dynamo, it will supply sufficient current for four 6-cp lamps, and as a motor it will be found useful for driving a sewing machine, a dental engine or a watchmaker's lathe, the pressure required to give the best results being 10 volts. Five cells of storage battery is recommended as being the most suitable source of power. The field magnets are arranged with alternate long and short yoke pieces, the two halves of the field



SMALL DYNAMO OR MOTOR.

being held together by a key pin passing through the long pieces of the yoke. The armature punchings of sheet iron contain eight slots for coils. The bearings and journals are carefully designed to give the most serviceable results, and either a flat or a round belt may be used on the pulley. The machine is designed for practical use, and affords amateurs an opportunity to become familiar with the construction and winding of such apparatus. It may also be had of the makers already assembled and ready for use.

The Utilization of Exhaust Steam.

The subject of utilization of exhaust steam appeals especially to electric companies, who either regard their exhaust steam as a wasted by-product, or one from which they get but small compensation by the use of condensers. It is a well-known fact that nearly ten times as many heat units in the form of steam must be generated as can be converted into mechanical energy through the medium of the steam engine. We find flowing from the exhaust pipes of the engines nearly 90 per cent of the steam after doing its power work, which, after heating feed water, is available for heating buildings. The Holly system takes this valuable product and turns it to practical account. It is the impression of some that exhaust steam is saturated with moisture and that it does not contain an equal number of heat units, as compared with live steam. This is a fallacy. Steam at equal pressures has equal temperatures. It is asserted from actual practice that the exhaust steam from each 100 horse-power of engines operated is sufficient to heat from 1,000,000 to 1,300,000 cubic feet of space in average buildings in zero weather, and that a fair commercial rate to charge for such heating depends upon the price of fuel in competition, varying from $2.50 to $5.50 per 1000 cubic feet of space per heating season. It will thus be seen that this valu-

able product can, when distributed to heat buildings, produce a revenue of from $2500 to $6000 per annum per 100 horse-power.

The American District Steam Company, whose main office and works are at Lockport, N. Y., are the originators and patentees of the Holly system of underground distribution of steam, and have built about 200 of these plants in different cities of this country. During the past year they have constructed some 20 new plants, besides making extensive additions to plants previously installed. Among the cities in which electric companies are operating the Holly system of exhaust steam heating are the following: Erie, Wilkinsburg, Washington, Johnstown, York, Towanda, Pa; Pawtucket, R. I.; Newburg, Hornellsville, Fredonia, N. Y.; Cumberland, Md.; Atlanta, Ga.; Seattle, Wash.; St. Joseph, Mo.; Danville, Champaign, Springfield, Ills.; Grand Rapids, Mich.; Youngstown, Ohio; Crookston, Minn.; Grand Forks, N. D., and many others.

Owing to the rapid increase in their business in the past year they have been compelled to double the capacity of their works to take care of orders. Electric companies operating the Holly system of exhaust steam heating report that they are paying all their expenses and interest on the investment for steam mains from the receipts from the sale of their steam, so they practically get their current free of cost. The company invite correspondence, and will gladly send their printed matter to any company or individual making inquiry.

Automobile Running Gears.

In the manufacture of automobiles the running gear comes next in importance to the motive power and its mechanism. The two gears illustrated herewith are made by H. F. Borbein & Company, 1113 Cass Avenue, St. Louis, Mo., with that point in view.

The gear shown in Fig. 1 has a 1¼-in. oil bearing front axle, pivoted steering device, connecting rods and steering lever with hickory axle bed; also hickory reaches, well ironed and braced, extending from front to rear axle. The rear axle is 1⅜ in. in diameter. The

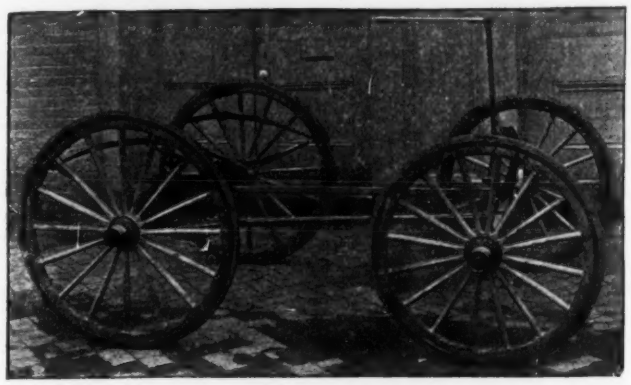


FIG. 1.—RUNNING GEAR COMPLETE.

wheels are Sarven patent wood wheels with 1¼ in. solid rubber tires. The tires are set in steel channels bolted to the rims. The front axle is pivoted so that the inside wheel will turn on a smaller circle than the outer wheel when going around corners, thus enabling the wheels to run freely without causing side creeping, and the undue

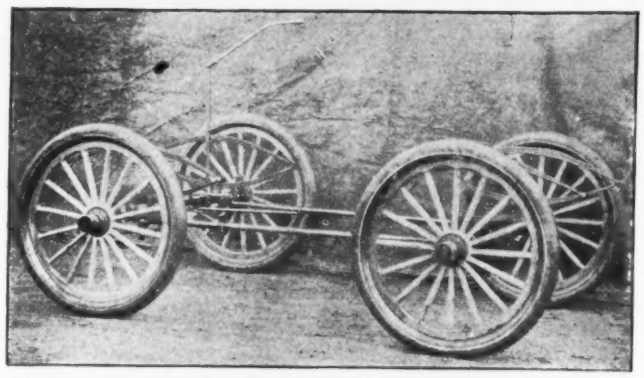


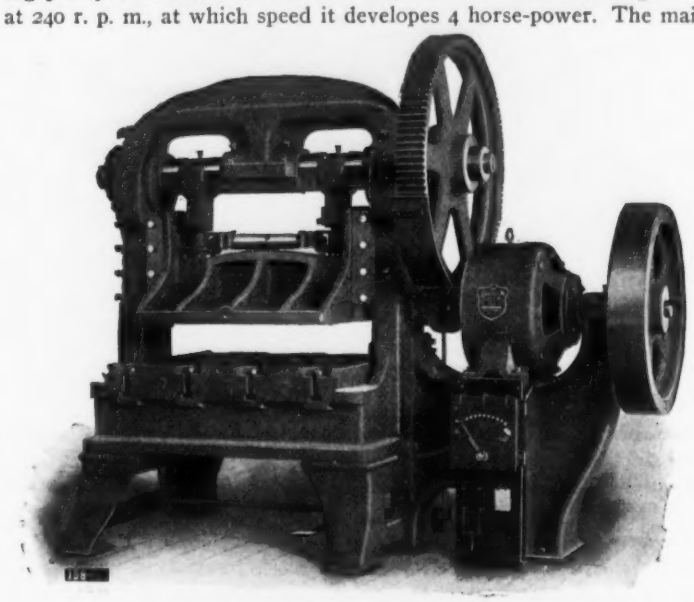
FIG. 2.—RUNNING GEAR.

wearing out of the rubber tires. The rear axle is provided with a differential gear which also allows the inside wheel to turn independently of the outer wheel when going around corners.

Fig. 2 shows a gear equipped with 1¼ in. roller-bearing front axle, and tubular reaches. The rear axle is 1½ in. in diameter. This gear is also equipped with Sarven wooden wheels and with 3 in. pneumatic tires, which are set on steel rims shrunk and keyed to the wooden wheels. This running gear has pivoted reach ends and will adapt itself to all kinds of rough and uneven roads. The regular gauge is 4 ft. 8 in., but the firm makes gears of any gauge desired. The distance between the front and rear axle is 5 ft., but this also may be made any length to suit individual requirements.

Electrically Driven Blanking Press.

The machine illustrated herewith is a Toledo punch directly driven by a Bullock motor. The motor occupies no more space than the driving pulley of a belted-driven machine, is series wound and operates at 240 r. p. m., at which speed it developes 4 horse-power. The main



BLANKING PRESS.

switch, fuse box and rheostat are mounted upon a board fastened to the motor support, as shown in the illustration.

This machine commends itself for its compactness and power and may be set upon a shop floor in any position without reference to line shafting. This feature makes it possible to effect great economy in floor space. This machine is one of the products of the Bullock Electric Manufacturing Company, Cincinnati, Ohio.

Telephone Exchange Apparatus at Pittsburg, Kan.

An interesting development of the telephone exchange switchboard is shown herewith. The board was built for the Pittsburg Telephone Company, Pittsburg, Kan. One section of the board is seen having a capacity of 300 instruments or subscribers, and arranged with positions for three operators. By adding other sections of the same size, the capacity may be increased to 600, 900, 1200 or any multiple of 300, up to an ultimate capacity of 3000 instruments. Boards of even larger capacity are made by the same company, but they vary somewhat from this, which is a metallic board and full multiple. It is simple, rapid and positive in operation, readily accessible in every part for connections, changes or repairs, and in every respect a most durable board. A full multiple board is so arranged that the operator can connect directly any instrument in her section with any other instrument, either in her own or any other section, thus giving her command over the whole switchboard. A great saving of time is thus effected.

For convenience, the board is divided into five panels and the plugs are placed on two different planes. It is provided with series jacks, and the subscribers' drops are restored by the operator. There are 18 pairs of cords and plugs for each operator, and the clearing-out drops are automatically restored. The lines coming from the cross connecting board pass through jacks in the first multiple, then continue to the next corresponding multiple. From the multiple jacks the wires go to the soldering tags on the intermediate field on the back of the board. This makes it possible to distribute the labor between the operators, which is done by removing busy subscribers from one operator and placing them with another who has more time. From these tags the wires are connected with the home jacks, which are placed on a sloping plane just above the table leaf, and from there they go to the subscribers' drops.

When the subscriber calls the exchange the drop falls and the operator places the answering plug, which is placed on the table leaf, in the

home jack, and at the same time pulls the lever of the table key toward the edge of the table to the speaking position. After ascertaining the desired number, the operator takes the ringing plug, which is on the sloping plane between the subscribers' jacks and the clearing out drops, and touches the jack in the multiple which corresponds with the desired line. If it is busy, there is a click heard in the operators' telephone, but if it is disengaged there is no sound, and in that

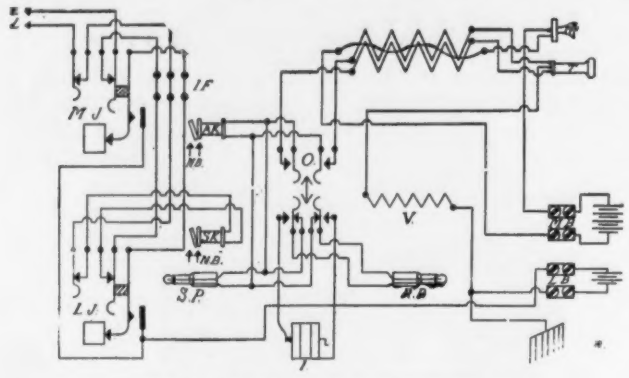


FIG. 1.—DIAGRAM OF CONNECTIONS.

L., Line.
M. J., Multiple Jack.
L. J., Home Jack.
S. K., Subscriber's Drop.
A. K., Clearing-out Drop.
I. F., Intermediate Field.
S. P., Speaking Plug.
R. P., Ringing Plug.
I., Generator.
M., Microphone.
O., Table Key.
N. B., Night Bell.
V., Busy-test Coil.
L. B., Test Battery.
M. B., Microphone Battery.
T., Telephone.

case the plug is placed in the jack and the second subscriber is called by pushing the lever of the table key toward the board to the ringing position. The table key returns automatically to its ordinary position, and the two subscribers are connected with each other.

When the conversation is finished, a ring-off signal is given and the clearing out drops fall and the plugs are removed by the operator. Each operator has a counter which automatically counts the calls issuing from the exchange. Six marked keys in pairs are fitted in front of each section. They are used for speaking and ringing to each of the two connected subscribers, separately.

If the operator desires to listen in or to speak to both the sub-

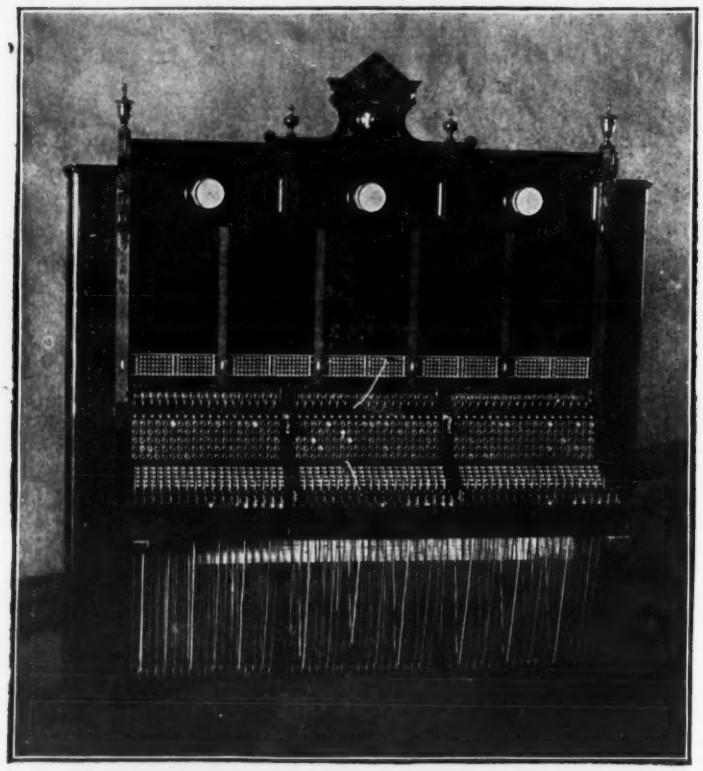


FIG. 2.—SECTION OF SWITCHBOARD.

scribers, the table key is pushed into its speaking position; but if connection with only one of them is desired, the keys are used. The call is generally given by the table key, but it can also be given by means of the other key. Both the subscribers' and the clearing out drops are provided with night contact, so that the night bell is rung when they are dropped. The diagram of circuits shows a portion of the connections in this multiple board.

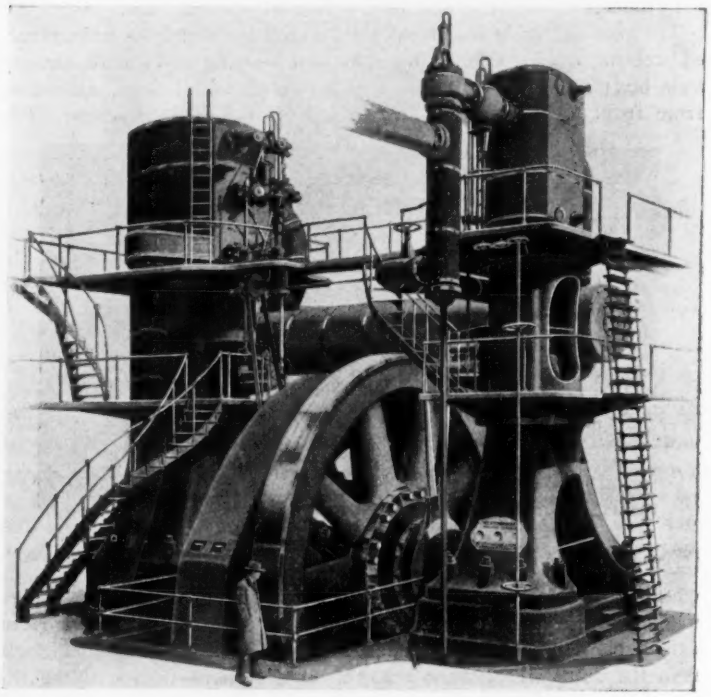
The board was built by L. M. Ericsson, Stockholm, Sweden, and sold by the Ericsson Telephone Company, 296 Broadway, New York City. Sales of boards of the same make have been effected to the Guthrie (O. T.) Telephone Company, Hedrick (Ia.) Telephone Company, Crow Telephone Company, Frank Pierce, Ia., Putnam County Telephone Company, Columbus Grove, Ia.; Montclair & Bloomfield Telephone Company, Montclair, N. J. An opportunity is thus afforded, moreover, in different parts of the country to inspect the apparatus in position. The Ericsson Company is introducing some new features in instruments also, to which it invites attention.

Engines for the Kings County Plant, Brooklyn, N. Y.

Two engines of 5000 horse-power each have just been finished by the Westinghouse Machine Company for the Kings County Electric Light & Power Company, of Brooklyn, N. Y.

One of these units is shown herewith. They are of the Westinghouse-Corliss type, vertical cross-compound condensing, and stand over 35 ft. above the floor. They are to be installed in the Bay Ridge station on New York Harbor.

Each engine comprises two vertical cylinders, erected side by side on massive frames, bolted to ponderous bed-plates. There is room left between the two cylinders for the Westinghouse alternating generator. The revolving part of the generator is mounted directly upon the steel shaft of the engine, and is firmly bolted to a very heavy fly-wheel, which has in the rim alone 100 tons of metal. It is 28 ft. in diameter, and the shaft which carries it is 39 ins. in diameter. It is



5000-HP VERTICAL CROSS-COMPOUND ENGINE.

not feasible to build so large a flywheel in one piece, and it is accordingly built in segments, keyed to each other and all bolted to the hub.

In addition to the great mass of the engine which is visible above the floor, a considerable depth below the floor is necessary to allow space for the fly-wheel and the lower frames of the great generator. Then, under all, when the machines are permanently installed, will be foundations of concrete. The over-all length of each of these engines is approximately 40 ft.

The engines are cross compounded with intermediate reheating receivers. The high and low pressure cylinders are of 46 ins. and 86 ins. diameter, respectively, and both are equipped with a new form of Corliss valve gear. The stroke is 60 ins. and the speed is 75 r. p. m. Steam is supplied at a pressure of 180 lbs., and the normal horse-power of the engines is from 4500 to 5000. In emergencies, however, each engine may be forced up to 7000 horse-power. The bearing shells and caps are water-jacketed, as are also the cross-head slides. The generators of the Westinghouse engine type have an output of 2850 kilowatts each, giving a three-phase current of 250 amperes in

each phase, at 6600 volts, with 3000 alternations per minute. They have separately excited fields and will operate in multiple with other Westinghouse units.

Building engines of such size calls for unusual shop and foundry facilities, and even their shipment is by no means an insignificant problem. Thus, for instance, the two bed-plates of one of these engines weigh over 43 tons each, and as they are cast complete in one piece they are very difficult to handle. For transporting these castings to Brooklyn the Pennsylvania Railroad has constructed special steel cars. The fly-wheel is, as we have said, built up in segments, and each of these segments is a car-load.

Time Switches.

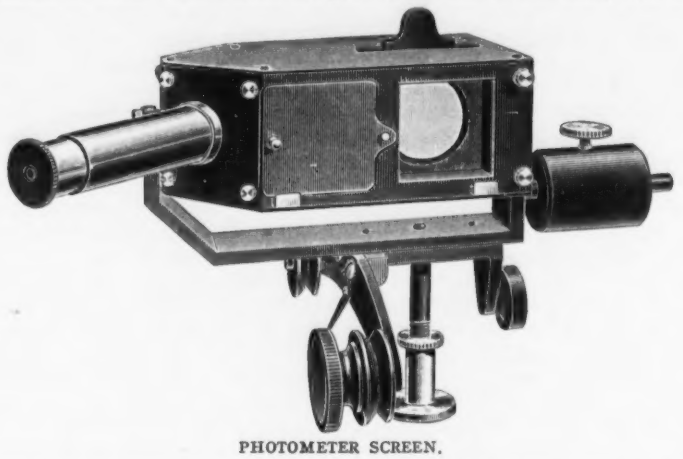
Switches operated by clocks to open or close the circuits, or both, have been worked on for years with results familiar to our readers. The illustration below shows a device which J. Jones & Son, of New York City, have just brought out. It is purely mechanical, the current going through the switch only, and it is made both to throw on and to turn off the current at any designated time once in 24 hours. The movement is 8-day and the winding of it once a week is all that is necessary. It is made up to operate on as high as 200 amperes on either direct or alternating circuits.

Photometer Screens.

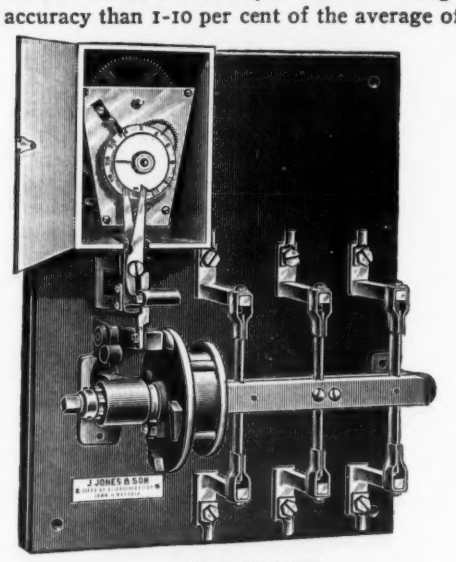
Among the many forms of photometer screens devised for comparing the intensity of sources of light, the Lummer Brodhun pattern is very generally in favor. It has a number of advantages, chief of which perhaps is the fact that the illumination produced by both lamps is viewed with one eye, the optical arrangement being such that the illuminated surfaces overlap, thus rendering the balance for equality very easy to make. This form of box, when properly constructed, enables the errors due to the absorption of the mirrors and inequality of plaster of paris screen to be eliminated if a sufficient number of readings are taken. In view of the fact that in the measurement of the candle-power of incandescent lamps by modern methods great speed is required, and one balance must represent the mean, within a small percentage, of a large number of readings, a new method was devised by Queen & Company, Inc., for adjusting these boxes. Such improvements have been made recently in the box illustrated herewith that the balance secured without the reversal of either the box or the screen may be taken as being correct to even a greater accuracy than 1-10 per cent of the average of 15 or 25 readings taken with the box set in all the various positions. The box illustrated herewith is guaranteed to reverse within 2 mm on a 2500 mm bar.

It is believed due to a considerable extent to the fact that both the prisms and mirrors used in this box are ground in the lens shop of Queen & Company, Inc., that such accurate reversal is made possible, as the best facilities are thus had for accurate work. Inasmuch as it is important in such boxes to keep the interior parts clean and free from dust, the sides are fastened with milled head screws so that no tool is required to open it for cleaning purposes.

The illustration shows the box mounted on a truck for the ordinary photometer track. This truck is so arranged that it will take the regular Bunsen sight boxes, which answer well enough for some classes of work. The wheels are grooved so that it will easily roll on any track up to 5-16 of an inch thick. There is also a convenient device for clamping the carriage at any desired position along the photometer bar.



PHOTOMETER SCREEN.

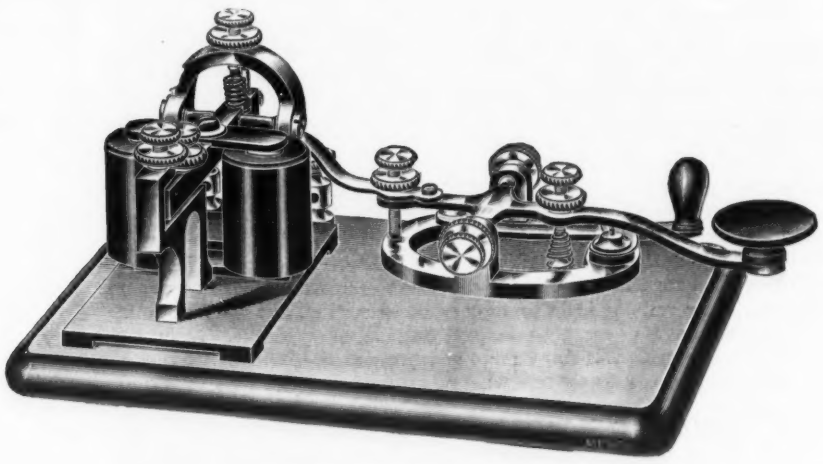


TIME SWITCH.

Combination Electrical and Mechanical Telegraph Instrument.

A novelty in telegraph instruments has just been brought out by the Manhattan Electrical Supply Company, New York. A standard 4-ohm sounder and a standard key, with an extension piece at the back of the lever, are mounted on one base. The sounder and the key are so placed that the sounder-lever and the key-lever lie in a position at right angles with each other. The extension piece of the key-lever projects back to the line of the sounder-lever and is bent upward sufficiently to bring its end into close proximity with the back end of the sounder-lever. A small hole is drilled vertically through the latter, near the end, into which a brass pin is loosely fitted. This pin is held at any height by means of a tightening screw. When it is allowed to drop down by gravity its lower end rests upon the key-lever extension and when fastened in this position it is evident that the operation of the key-lever will operate the sounder-lever mechanically. By raising the pin so as to clear the key-lever extension, and fastening it in place, the instrument may be operated by battery current in the usual way, all of the proper electrical connections being provided for the purpose. Thus, it will be seen, the instrument is both mechanical and electrical in its operation. The former feature will render the instrument of particular value for teaching and practice, and, worked electrically, it may be used on short telegraph lines. With properly wound magnets it could, of course, be used on longer lines, and yet it would be as available for mechanical operation.

In all respects the instruments are of the highest standard in material and finish and the two-fold usefulness of the outfit will no doubt be much appreciated.



COMBINATION TELEGRAPH INSTRUMENT.

NEWS OF THE WEEK.

Financial Intelligence.

THE WEEK IN WALL STREET.—Call money was abundant last week at 3@6 per cent, 5@5½ per cent being the ruling quotations. The rates for time money are 4@4½ per cent for 30 to 60 days, and 4@5 per cent for longer periods. Commercial paper is quiet, prime double names being quoted at 4½@5 per cent. Several factors contributed toward creating a bullish stock market, among the principal of which were the influx of investment buying and more liberal public participation. Transactions on the Stock Exchange were on an enormous scale, and almost all classes of stocks showed advances on the week's business, some high-priced dividend payers being strong and high. Low-priced stocks were active and higher. In the electrics and tractions higher prices are the rule. General Electric went as high as 200 during the week, closing at 193, ex-dividend. Brooklyn Rapid Transit closed with a net gain of 2¼ points, the sales for the week aggregating 224,290 shares. Metropolitan Street Railway closed at 171, ex dividend, a net loss of 1½ points. Western Union fluctuated between 82½ and 85⅛, closing at 85, a net gain of ½. In the market for outside securities there was little activity, although some substantial changes were recorded. The large transactions on the Stock Exchange seemed to draw business away from "curb" trading. The market, on the whole, was erratic, the irregularity being most apparent in several active issues. Among the advances were Electric Vehicle, common, 2½; do, preferred, 10; among the losses were Electric Boat, common, 1½; do, preferred, 1. Following are the closing stock quotations in the four cities named:

NEW YORK.

	Dec. 22.	Dec. 29.		Dec. 22.	Dec. 29.
Gen. Electric	196	193	Elec. Veh.	16	19
Bklyn. Rap. Tran.	83¾	86	Elec. Veh., pfd.	35	45
Met. St. Ry.	174½	171	Gen. Car.	3¾	4¼
Am. Tel. & C.	—	—	Ill. Elec. Veh. Tran.	1	1
West. Un. Tel.	83½	84	N.Y. Elec. Veh. Tran.	6½	6½
Am. Dist. Tel.	—	36½	N.E. Elec. Veh. Tran.	3	3¼
Com. Cable	—	—	Tel. & Tel. Co. of Am.	2¼	2¼
Elec. Boat	29	27	Hud. Riv. Tel.	115	116
Elec. Boat. pfd.	49	48	N. Y. & N. J. Tel.	168	173

BOSTON.

	Dec. 22.	Dec. 29.		Dec. 22.	Dec. 29.
New Eng. Tel.	—	—	Erie Tel.	100	100
Mex. Tel.	2¾	2¾	Gen. Elec., pfd.	—	155
Westing. Elec.	55¾	56*	Am. Tel. & Tel.	155	155
Westing. Elec. pfd.	—	—	Ed. Elec. Lt.	—	—

PHILADELPHIA.

	Dec. 22.	Dec. 29.		Dec. 22.	Dec. 29.
Elec. Stor. Bat.	—	88	Phil. Elec.	4¾	5⅛
Elec. Stor. Bat., pfd.	90	90	Pa. Elec. Veh.	3	2
Elec. Co. of Am.	9	9¾	Pa. Elec. Veh., pfd.	1	1
Gen. Elec. Auto.	—	—	Am. Rys.	33⅝	33

CHICAGO.

	Dec. 22.	Dec. 29.		Dec. 22.	Dec. 29.
Chicago Edison	145	145	Chicago Telep. Co.	240	235
Chic. City Ry.	253	253	Union Traction	11¼	11¼
Nat'l Carbon	16¼	16	Union Traction, pfd.	44½	45¼
Nat'l Carbon, pfd.	84½	83¼	Northwest Elev. Com.	29	28½

*Asked.

LONDON FINANCIAL SMASH.—There has been a mining smash in London, which may have some effect on one of the underground railway schemes, Mr. W. Wright being a central figure in the troubles. Whitaker Wright is about 55 years of age and has been operating in London for about 10 years. He formed the London & Globe Finance Corporation, which bought West Australian mines of marvelous richness but of doubtful enduring capacity. Among them were the Lake Views, which returned half a million dollars a month and whose £5 shares advanced to £28. Wright then broadened out in the banking world and undertook the financing of the Baker Street Underground Railway in London to the tune of $20,000,000; in fact, he subscribed for the entire issue of bonds to the amount of £4,000,000 sterling. The railway is in process of construction, but the bonds, it is believed, have never been floated outside of Whitaker Wright's banking resources. His third great venture was the British-American Corporation, where $7,500,000 was subscribed and the market value was swollen to $25,000,000.

NEW ENGLAND ELECTRIC VEHICLE COMPANY.—George von L. Meyer has retired from the presidency of the New England Electric Vehicle Transportation Company to fill his post as Ambassador to Italy. Francis R. Hart, vice-president of the Old Colony Trust Company, has been elected president. There has been a readjustment of the executive department of the company, by which some of the executive duties of the president will be performed by a vice-president. John Balch, of Boston, has been elected a vice-president for these duties. He will also assume the executive duties of the treasurer, T. K. Cummins, Jr., who has recently been appointed secretary of the Bay State Trust Company. Mr. Cummins has been elected a director of the Transportation Company and it is understood that he will retain the treasurership for the time being. William A. Burroughs has been elected secretary in place of Mr. Cummins, resigned. Charles L. Edgar, president of the Edison Electric Illuminating Company, remains a vice-president, and Knight Neftel chief engineer and general manager.

BOSTON LIGHTING CONSOLIDATION.—It is announced from Boston that the efforts which have been making for four years now to unite the Edison and the Boston Electric Light Company are about to succeed, if, indeed, they have not succeeded already. A meeting of the stockholders of each corporation will be held within a fortnight. Each company pays 8 per cent dividends and earns a great deal more. The new plan is to eliminate competition and to enable the stockholders to receive the largest surplus earnings. Both the present companies, according to the plan, are to be leased to a new company, which will agree to pay 10 per cent on each stock, giving to them an almost immediate market value of $240 or $250 a share, against $215, the value lately. The stock of the new company is to be offered to the stockholders of the two present companies, pro rata, and it is expected that the surplus earnings and increased business will pay large dividends upon this new issue.

DIVIDENDS.—The Binghamton (N. Y.) General Electric Company has declared a regular semi-annual dividend of 2 per cent, payable Jan. 10. The New London (Conn.) Street Railway has declared a semi-annual dividend of 2 per cent, payable Jan. 1. The Consolidated Traction Company of New Jersey has declared the regular semi-annual dividend of 1 per cent, payable at that rate until 1902, out of $150,000 received from the North Jersey Street Railway Company for the operation of the Consolidated Traction lines in Jersey City and Newark. The United Power & Transportation Company has declared a semi-annual dividend of $1 per share, payable Jan. 21. The directors of the New York & New Jersey Telephone Company have declared the regular quarterly dividend of 1½ per cent, and an extra dividend of 1 per cent.

MASSACHUSETTS ELECTRIC COMPANIES.—At a meeting of stockholders of the Massachusetts Electric Companies it was voted to issue at once $2,700,000 4½ per cent coupon notes for the purpose of purchasing stock in the sub-companies, recently authorized by the Railroad Commissioners, and retiring floating debt. The indenture also provides for an additional issue of notes to the amount of $800,000 to purchase, in the future, stock of sub-companies that may be issued for improvements under the plan of consolidating the properties.

INCREASE OF METROPOLITAN CAPITAL.—A certificate of the increase of the capital stock of the Metropolitan Street Railway Company from $45,000,000 to $52,000,000 was filed at Albany on Dec. 21 with the Secretary of State. The certificate says that the debts and liabilities of the company amount to $32,750,000.

Commercial Intelligence.

THE WEEK IN TRADE.—In the retail trade last week there was unprecedented activity, due largely to the holiday season. In the wholesale trade business was of reasonably small proportions, but reports from leading lines, such as iron and steel, lumber, glass, etc., were encouraging. All sections of the country report excellent business. New business in iron and steel was well sustained and quite good during the week. Free sales of finished products and of hardware are reported from Chicago, at which point 15,000 tons of rails were taken. In the metal market weakness and inactivity prevailed, there being but two business days during the week in this market. Copper quotations are unchanged, lake being 17c and electrolytic and casting 16⅝c. According to *Bradstreet's*, the number of failures last week was 213, against 262 the week previous and 220 the same week last year. The same authority states that railroad earnings continue very good, the gain of 7 per cent in gross for the second week being followed by a gain of 9 per cent for the third week of December.

THE GENERAL ELECTRIC COMPANY reports that the business done during the year 1900 shows a large increase over that done in 1899, notwithstanding the fact that the latter year's business was the best in its history. We gave some data recently as to this business. By means of enlarged facilities in its workshops this company has been enabled to make deliveries keep pace with increased orders. The number of new projects requiring large quantities of electrical apparatus and supplies has been noteworthy during the year, and final deliveries have been made on several large outstanding orders. The prices of the raw materials chiefly used in the electrical work remained at the high record made during the year 1899 until November last. Since then actual advances have been demanded on these prices, which, if continued, must ultimately lead to increased prices for finished electrical products. During the year noted improvements have been made in the equipment of central station lighting apparatus, the older and more inefficient types of generators and devices having been discarded and replaced by larger units of higher efficiency and of a

more substantial character. In electrical railway work there has been a decided tendency to use equipments of four motors instead of two, thus giving greater power, higher speed and generally more satisfactory service. The increasing demand for railway equipments for suburban and interurban work shows clearly the tendency on the part of all railway companies to extend their lines. So rapid have been the strides in the successful transmission of power by electricity over considerable distances that the limiting factor is no longer the length of the transmission line, but is now merely a question of the market price at which the power can be sold. Power at a loss of only 8 per cent on the line is to-day being transmitted 80 miles in California. The electrical transmission of power from coal mines—using slack for fuel—is now beginning to attract the attention of capitalists, and at the close of the year 1900 there are several plants of this character in different sections of the country which have proved to be great commercial successes.

EXPORTS OF ELECTRICAL MATERIAL.—The following were the exports of electrical material and kindred lines from the port of New York for the week ended Dec. 26: Amsterdam—7 packages electrical material, $274. Athens—4 packages electrical material $10. Antwerp—181 packages electrical material, $9,759. Argentine Republic—191 cases electrical material, $5,249; 20 cases electrical machinery, $1,667. Bremen—1 case electrical machinery, $200; 4 packages electrical material, $69. Bilbao—23 cases electrical material, $717. Brazil—363 packages electrical material, $14,194; 10 packages electric railway material, $1,102. Birkenhead—2 cases electrical machinery, $462. British Possessions in Africa—4 cases electrical machinery, $862; 103 cases electrical material, $8,159. British Guiana—35 cases electrical material, $1270. British West Indies—89 cases electrical material, $2,852; 2 cases electrical machinery, $58. Chili—1 case electrical material, $14. Central America—130 packages electrical material, $1,666; 2 cases electrical machinery, $255. Cuba—79 packages electrical material, $2,548; 4 cases electrical machinery, $760. Ecuador—33 packages electrical material, $796. Glasgow—102 cable reels, $42,667; 6 cases electrical material, $164; 122 packages electrical machinery, $34,236. Havre—78 cases electrical material, $9,374; 3 cases electrical machinery, $2,500. Hayti—3 packages electrical material, $61. Hamburg—105 cases electrical material, $11,993. Liverpool—41 packages electrical machinery, $5,339; 67 packages electrical material, $4,792. London—31 packages electrical machinery, $4,442; 237 packages electrical material, $17,415. Mexico—4 cases electrical material, $355. Newfoundland—15 cases electrical material, $443. Nova Scotia—11 cases electrical material, $124. Newcastle—39 cases electrical material, $4,400; 6 cases electrical machinery, $1,000. Portuguese Possessions in Africa—31 packages electrical material, $2,185. Porto Rico—14 packages electrical material, $942. Peru—79 packages electrical material, $3,375. Southampton—51 cases electrical material, $3,153. St. Petersburg—12 cases electrical material, $355. United States of Colombia—4 cases electrical material, $200. Vienna—9 packages electrical material, $154. Venezuela—15 packages electrical material, $259. Wallsend—30 packages electrical machinery, $6,392.

THE GROWTH OF EXPORT TRADE.—The United States seems likely to stand at the head of the world's list of exporting nations in the year 1900. During the past five years, only the United Kingdom and the United States could be considered as competitors for the distinction of being the world's greatest exporter of articles of home production. In 1894 the United Kingdom led the United States by nearly $250,000,000, and in 1897 the United States had so rapidly gained that she was but $60,000,000 behind. In 1898 the United States took first place, our exports in that year exceeding those of the United Kingdom by nearly $100,000,000. In 1899 the United Kingdom again stood at the head of the list, her exports exceeding those of the United States by nearly $35,000,000. In the eleven months of 1900 whose figures have been received by the Treasury Bureau of Statistics, the domestic exports of the United States exceed those of the United Kingdom by $5,473,670, and should this rate of gain be maintained in December the United States will in the year 1900 show a larger exportation of domestic products than any other nation in the world. Even this distinction, however, of heading the world's list of exporting nations but partially tells the story of our export trade as measured by that of other nations. Comparing the growth of exports during the last quarter of the century with those of the other great nations of the world, we are able to better measure the wonderful progress shown. France shows no increase in her exports of domestic merchandise in the closing quarter of the century; Germany shows during the same period an increase of about 50 per cent, and the United Kingdom shows from 1875 to 1900 an increase of nearly 40 per cent, while the United States shows during that time an increase of practically 200 per cent.

WESTERN TELEPHONE CONSTRUCTION COMPANY.—During the past eight months this company has, under its new organization and management, done a most successful business. The cities to be equipped by the "Western" are Pottsville and Williamsport, Pa.; Corsicana, Tex.; Greensboro, N. C., and Binghamton, N. Y. In addition to the contracts named it has also recently shipped a 200-line "Western Express" switchboard to J. P. Helfenstein, Ashland, Pa., and has booked orders for 100-line "Western Express" switchboards for the Columbia Telephone Company, Columbia, Pa.; Mutual Telephone Company, Greenfield, Ohio (for Leesburg, Ohio); J. B. Rhodes, Zanesville, Ohio; Lancaster Telephone Company, Lancaster, Ky., and smaller orders for other points. Large orders for telephones have been recently filled for Leesburg and Eaton, Ohio; also an additional order for telephones from the Chicago & Alton Railroad for their lines between Chicago and Bloomington. Orders for the new "Western Express" No. 3 bridging telephones are very satisfactory. The strength and size of generators and the good ringing qualities of these instruments have caused their adoption by many farmers' lines and long distance companies.

NORCROSS BROTHERS, of Worcester, Mass., who have the contract for constructing the magnificent new plant of the Natural Food Company at Niagara Falls, have commenced work on their contract with great vigor. Many men and teams are at work, and, as fast as they can be utilized, the working force is being added to at every point in expectation that the factory and institute may be completed in time for opening with the Pan-American Exposition, May 1. Electric power will be used in every possible way in order that the plant may be perfect in its workings and cleanliness. President H. D. Perky has taken possession of the home of Mr. W. B. Rankine, which he purchased, and he is now a resident and citizen of Niagara Falls. Naturally, Niagara Falls people feel much elated over William B. Rankine's success in capturing this fine new industry for that city. The structural material has already begun to arrive at the Falls in large quantities.

TELPHERAGE.—With the opening of the new century, telpherage comes forward as a new art, and is at once finding its place and function for light transportation, particularly in regions where it is not desirable to lay trolley tracks or where there may not be traffic enough to warrant the installation of an expensive rail system. The capacity of the telpher to handle large quantities of material in the aggregate is nothing short of remarkable. The Consolidated Telphage Company, of this city, whose organization is due to Mr. H. McL. Harding, is now executing some interesting contracts and is receiving inquiries and requests for bids from all parts of the world. A large number of agencies have been applied for and appointed, and there hardly seems to be a country or an industry that does not need this latest of the electrical arts on a large scale.

NEW CORLISS ENGINE WORKS.—A stock company has been formed at Milwaukee whose object is the construction and the operation of a new plant for the manufacture of Corliss steam engines. The name of the concern will be the Brown-Corliss Engine Company, and the management will consist of the following: T. W. Phillips, of Providence, R. I., president; W. F. Brown, of Milwaukee, superintendent; Chas. Rhode, of Milwaukee, treasurer. C. M. Paine is handling the financial end of the deal. The capital stock of the corporation is to be $1,000,000 and will consist of 5000 shares of preferred and 5000 shares of common stock. The plans and articles of incorporation are drawn up and will be placed before the public in a short time. The factory will be located at Milwaukee.

MANHATTAN ELECTRICAL SUPPLY COMPANY.—As already noted in this department, the Manhattan Electrical Supply Company, of New York City, in pursuance of its aggressive forward policy, is branching out in various directions. Its latest departure, which is of interest to the supply trade and to electrical people in general, is the securing of the whole store and basement at 186-188 Fifth Avenue, Chicago. It will take a little time to fit up and stock this well-known piece of property, and then the company will open there for that part of its growing Western trade early in the new year.

ELWELL-PARKER ELECTRIC COMPANY.—We understand from President F. C. Phillips that the Elwell-Parker Electric Company of Cleveland, Ohio, whose works were destroyed by fire recently, together with those of the Brown Hoisting Machinery Company, have been fortunate enough to secure temporary premises that are considerably larger than the old ones. They will be in full swing with their new facilities and ready to take and fill new contracts by Jan. 1. Fortunately, also, insurance is going to about cover all the actual property loss.

MR. W. R. MASON, who of late has been representing in St. Louis the Siemens & Halske Company of America, will act, after Jan. 1, as district manager for the Northern Electrical Manufacturing Company, Madison, Wis., and the Stanley Electric Manufacturing Company, Pittsfield, Mass. His office will be at 110 Laclede Building, in that city.

W. J. MURDOCK & CO., of Boston, Mass., the manufacturers of the new "Solid" telephone receiver, are removing their factory and office to Chelsea, a suburb of Boston. The new plant, which is on Carter Street near Edward Avenue, will increase its capacity very largely.

Special Correspondence.

ENGLISH NOTES.

LONDON OFFICE ELECTRICAL WORLD AND ENGINEER,
Dec. 20, 1900.

MR. SLATER LEWIS has retired from the position of engineer and general manager to P. R. Jackson & Co., of Manchester, England, and has accepted a seat on the board of the Brush Electrical Engineering Company, Ltd.

UNDERGROUND ROADS.—The rapid development of underground railway schemes and work in London is said to be having an effect in Paris. It is now stated that the municipality have under consideration another underground railway from Montmartre to Montparnasse. It would cross beneath the Seine through two tunnels, join three important railway stations—St. Lazare, Orleans and Montparnasse—and form the connecting link between the metropolitan and the circular underground lines building. The proposed railway would be a great boon to Parisians.

NERNST ELECTRIC LIGHT.—The report of the directors of the English Nernst Electric Light Company, from Feb. 23, 1899, to Sept. 30 last, states that the expenditure on capital account during this period is shown to have been £9,696, while the disbursements on other accounts amount to £6,757. The directors, after deducting from the latter amount £846, received on account of interest and transfer fees, have placed the balance of £5,911 to a development suspense account, to be dealt with in future years. Apart from the purchase consideration for the patent rights, the only prominent item of expenditure on capital account is £5,000 contributed toward the purchase for this company of Professor Nernst's British royalties, the balance of the consideration having been provided by the vendors. As the owners of the British rights have not commenced business in England, this investment is still unproductive. Since the formation of the company the directors have been engaged in further developing the Nernst lamp, so as to render it more capable of being manufactured and sold in quantities on a profitable commercial scale, and with a uniform degree of quality and efficiency for the various sizes; they have also taken out subsidiary patents, which, it is hoped, will prove of considerable value. The fire which occurred on the company's premises in May unfortunately destroyed the patterns, instruments and apparatus collected during the previous twelve months, and, notwithstanding the most strenuous efforts of the staff, progress was practically arrested for more than three months. While every discovery involving radical changes from existing methods must necessarily take time before the result can safely be placed on the market, the directors have found that the practical difficulties to be overcome in the wholesale reproduction of the Nernst lamp to the best advantage have been greater than they anticipated. The variations which occurred in endeavoring to repeat on a more extensive scale results already obtained have involved lengthy experiments and chemical research in directions where no precedent was available. It is now, however, confidently hoped that the main causes of such variations have been traced to their origin, and means devised for their elimination. It should be considered that, although all the licensees possessing rights for other parts of the world commenced work many months before the formation of this company, and had, in most cases, the advantage of an organization already equipped, this company has, in the opinion of the directors, made at least as rapid progress in the practical development of the lamp as other concessionaires. According to the balance-sheet, the development suspense account amounts to £6,757, less interest, etc., £846. The annual meeting was a stormy affair, when charges were made against the managing director, and adjournment was taken for a month.

General News.

THE TELEPHONE.

CANAL WINCHESTER, OHIO.—The Columbus Citizens Telephone Company is preparing to establish a branch exchange at this place.

ELMORE, OHIO.—The Home Telephone Company recently organized by local people is installing its exchange. A large number of subscribers have been obtained.

YOUNGSTOWN, OHIO.—Harry Koplin, formerly of the Youngstown Telephone Company, has been appointed superintendent of the Columbiana County Telephone Company.

TOLEDO, OHIO.—It is reported that a company with $1,000,000 capital stock will be incorporated for the purpose of establishing an independent telephone system in this city.

MONROVIA, CALIF.—The Monrovia Telephone Company is operating a system connecting villages in the orange-growing districts. The Monrovia exchange has 82 subscribers and a switchboard capacity of 100 drops.

CALEDONIA, OHIO.—John Pommert has commenced work on a local exchange, and thus far has secured 50 subscribers. Next spring he expects to connect with Marits, Adelaide, New Winchester, Kirkpatrick and other surrounding towns.

YOUNGSTOWN, OHIO.—The Central Union Telephone Company is preparting plans for a large six-story office building, part of which will be utilized for its offices and local exchange. New switchboards will be installed, and the facilities will be greatly increased.

CLEVELAND, OHIO.—The Cleveland Telephone Company is having trouble with its toll stations throughout the city through slugs and counterfeits. The number of boxes being broken into indicates that there is an organized gang at work. One night recently forty boxes were reported broken into and their contents abstracted.

SPRINGFIELD, OHIO.—J. J. Dunn, of Columbus, and D. F. Snyder, of this city, are promoting a company which will be incorporated with $150,000 capital stock, to build an independent telephone system in this place. A franchise will be applied for in the near future, and it is believed it will be secured without difficulty.

CADIZ, OHIO.—The Harrison County Telephone Company has been incorporated by A. J. Vernier, C. D. Duvenal, J. M. Schreiber, W. W. Wright, W. W. Potts and R. Cunningham. Capital stock, $25,000. The company will build a local exchange with toll lines in Carroll, Belmont, Guernesey, Jefferson and Tuscaraws counties.

NEW HAVEN, CONN.—The Automatic Telephone Company, of Waterbury, Conn., organized some two years ago, under the Joint-Stock Law of the State, has filed application to the State Legislature for a special charter. It ceased any further steps toward doing business when last year, Judge Thayer in the Superior Court found against the public necessity and convenience of a similar company seeking to do business in New London.

CLEVELAND, OHIO.—The Stark County Telephone Company, which is composed of local people, and which is building exchanges at Canton, Alliance and other places, has organized as follows: Joseph Beichele, president; J. B. Hoge, vice-president; Ferdinand Herbruck, treasurer, and James E. Flohr, secretary. Directors: Ferdinand Herbruck, Augustus Dannemiller, T. H. Phillips, Joseph Beichele, John C. Welty, H. D. Critchfield, J. B. Hoge, Harry A. Cavanah and R. S. Shields.

CONNECTICUT.—The Southern New England Telephone Company has announced an important reduction in the private and business rates of all Connecticut towns where there are less than 160 subscribers. The rates for house party service is reduced 25 per cent., and for business offices 33⅓ per cent. The towns affected are Brandford, Danielson, Guilford, Litchfield, Manchester, Milford, Naugatuck, New Milford, Ridgefield, Rockeville, Southington, Saybrook, Simmsbury, Wallingford and Winsted, and their connecting towns.

SALEM, OHIO.—The Independent Telephone Association, of Columbiana County, was organized here a few days ago for the purpose of making a closer alliance among the independent companies in this vicinity. Lewis H. Walker, of the Eastern Ohio Telephone Company, was elected president, and W. F. Crossley, of the Columbiana County Telephone Company, secretary. Representatives of the Bayard, Winona and Damascus companies, with the above mentioned, were chosen as an executive board. It is believed the new association will tend to improve the service of all the companies interested.

INDIANAPOLIS, IND.—Hugh J. McGown, of this city, who is a director in the American Telephone, Telegraph & Cable Company, says that the company is responsible for the consolidation of telephone interests recently made in the South. He says the company is progressing with its plan of extending the use of telephones to the rural districts. The extension work will be pushed more rapidly when the company brings about closer relations between existing telephone companies now controlling certain large districts in the Eastern, Central and Central West States.

ELECTRIC LIGHT AND POWER.

NEW ORLEANS, LA.—The Merchants' Electric Light & Power Company has sold out to the Merchants' Electric Company.

SANFORD, N. C.—There is an opening here for an electric light plant. Mr. W. A. Wynne, of Raleigh, N. C., may be addressed on the subject.

NICHOLASVILLE, KY.—The Mayor has appointed a committee to investigate the advisability of establishing a municipal electric light plant here.

CLEVELAND, OHIO.—The village of East Cleveland has practically decided to erect a municipal lighting plant. A council committee is having plans and estimates prepared.

BLOOMINGTON, IND.—Indianapolis capitalists represented by Councilman S. V. Perroll is proposing to purchase the Bloomington Electric Light plant, and have secured an option.

SAN FRANCISCO, CALIF.—The Union Iron Works are building an extension to their electric power house, in which additional boilers, generating sets and an air compressor will be installed.

PARRY SOUND, ONT.—A by-law to raise $30,000 to purchase the electric-light plant of the town of Parry Sound, Ont., will be submitted to a vote of the ratepayers of the town in January next.

HOOD RIVER, OREGON, will soon have electric lights. A local company has commenced the construction of a water power electric power system to be supplied from Hood River near the town.

INDIANAPOLIS, IND.—The county power, heat and light plant has been accepted by the County Commissioners from the contractors, Joseph McWilliams & Co., of Louisville. Its cost was $150,000.

MONTPELIER, IND.—The City Council has voted to purchase the local plant of the Montpelier Electric Light Company of the Kerlin Bros., of Toledo, O., owners thereof. The contract price is $38,000.

SLOCAN, B. C.—A company has been formed here for the purpose of securing a water power from Goat Creek, near this place, and to develop electric power. The estimated cost of the works is placed at $40,000.

WASHINGTON, D. C.—The U. S. Signal Corps at its post at Fort Myer, Va., is installing an electric generating plant for charging the storage batteries of the automobiles at that post, and also for purposes of instruction.

MT. GILEAD, O.—The Mt. Gilead Water & Electric Light, Heat & Power Company has been incorporated with a capital stock of $60,000. Mr. J. C. Fish, of Shelby, O., is manager. The company's plant has not yet been installed.

HAMILTON, OHIO.—The capacity of the electric light plant here is inadequate to meet the demand for light. It has been estimated that an additional plant will cost about $50,000, which will require the issue of bonds by vote of the people.

TERRA ALTA, W. VA.—The Terra Alta Light, Heat & Power Company has been incorporated with a capital stock of $10,000. Mr. J. F. Gienger is

manager. The company is in the market for equipment. Its power house has not yet been built.

YOUNGSTOWN, OHIO.—The Youngstown Consolidated Gas & Electric Light Company has submitted a proposition to the city to furnish 300 arc lamps, or as many more as are needed, at the rate of $64 per year; contract to remain in effect for nine years. The proposition will be accepted.

ST. LOUIS, MO.—The bill for the erection of a municipal lighting plant at the city waterworks has passed the Council. It authorizes work to commence on installing the new electric plant at once, and it is expected it will be in operation by September 1, 1901. The annual saving to the city is estimated at $10,000.

SIDNEY, B. C.—A company composed of American capitalists has been organized by J. Keith Fisher, of the British Columbia Portland Cement Company, the object being to establish extensive cement works near Sidney, on Vancouver Island, B. C. It is intended to operate the works by electric power.

SAN BERNARDINO, CALIF.—The San Bernardino Gas & Electric Company was recently incorporated with San Bernardino, Cal., as the place of business. Directors: Charles R. Lloyd, of San Francisco; W. S. Hooper, W. F. Gordon, J. W. Curtis, San Bernardino; E. D. Roberts, Colton. Capital stock, $200,000; subscribed, $500.

KINGSTON, ONT.—The corporation of the city of Kingston has served notice on the Kingston Light, Heat & Power Company of the city's intention to proceed, under the terms of an agreement existing between the city and the company, to arbitrate and fix a price for the purchase of the gas and electric light plants from the company. The value of the plants aggregate $300,000.

DENVER, COLO.—Suit has been brought in the District Court against the Lacombe Electric Company, attacking the validity of the ordinance by virtue of which the company is now installing its system for the purpose of supplying electric light to the city. The suit was brought on the grounds of publication only, it being alleged that the bill granting the franchise was not published in a daily paper as required by law.

CINCINNATI, OHIO.—Attorney Charles H. Shaw, representing the New York syndicate, which purchased the Suburban Electric Company's plant in Covington, says the question of confirmation of sale is up to the courts and that Jan. 10 has been set for a hearing. Attorney Shaw believes the sale will be confirmed, as the charge that the sale was not held on the day indicated in the order was due merely to oversight and was not premeditated.

NEW ULM, MINN.—The city council has under consideration the advisability of installing an electric light plant for the city, and steps are being taken looking toward favorable action in the near future. The committee on lights will receive plans, specifications and estimates of the cost for a plant of 100 street arc lights of 2000 candle-power, with all necessary machinery. For further information application can be made to Louis Schilling, city clerk of the City of New Ulm, Minn.

BROCKVILLE, ONT.—Some time ago the city of Brockville purchased the plant of the Brockville Gas & Electric Light Company for $85,000, on a valuation by a Toronto civil engineer. The Brockville light commissioners, however, recently engaged a New York expert named Mr. Blossom, to make an inspection of the plant. Mr. Blossom's report has come to hand, and it practically condemns the whole plant which is not only stated to be out of date, but also in a very bad condition. The value of what material might be utilized would be about $30,000, but the wiring, etc., is of little account. To repair the systems, as they now stand, would cost about $63,000. Mr. Blossom favors concentration of the two plants and building an entirely now system at an estimated cost of $125,000.

MINNEAPOLIS, MINN.—The International Electric Company, whose big plant in the Lumber Exchange and Edison Building was installed at a cost of $150,000, has been sold to Eastern parties, who have already taken charge of the property. The transfer was effected through the Old Colony Trust Company, of Boston, acting as agent for Eastern capitalists, who have been negotiating with the local stockholders for weeks. The International Electric Company was organized in 1894 with H. C. Akeley as president. Its plant and main offices are located in the Lumber Exchange and Edison Buildings. The company's lighting operations have been principally confined to the downtown district, and cover the territory from the river to Thirteenth Street and between Fourth Avenue South and Third Avenue North. This territory comprises what is known as the underground district. The company is at present supplying about 10,000 lights, and has been running to the limit of its capacity for some time.

THE ELECTRIC RAILWAY.

OKLAHOMA CITY, OKLA.—A franchise has been granted to a company of Chicago capitalists to construct and operate a street railway here.

FORT WORTH, TEXAS.—Bids will probably be opened and the contract let Jan. 10 for the construction of the inter-urban electric road to Cornear, Fort Worth and Dallas.

CHARLOTTE, N. C.—It is stated that Dr. Pratt, of Chapel Hill, N. C., who is interested in the proposed electric railway to Durham, N. C., has raised about $200,000 toward the enterprise and that he is now working for an additional $100,000.

ST. LOUIS, MO.—The new position of second vice-president of the Transit Company has been filled by the appointment of A. B. Dupont, general manager of the Citizens' Street Railway Company, of Detroit, Mich. Mr. Dupont will take up his new duties Jan. 1.

GALVESTON, TEX.—The charter of the Galveston City Railway Company has been filed at Austin, Tex. Its capital stock is $800,000. The incorporators are R. B. Baer of Houston, Walter G. Oakman, George H. Turnbull and Edward Cornell of New York City.

ST. LOUIS, MO.—The St. Louis, Clayton & Western Railway Company, which was granted a franchise for an electric road in the county two years ago, has made application for further time in which to accept the provisions of the county court, and was given until Feb. 1, 1901.

TIFFIN, OHIO.—President Sneath, of the Fiffin, Fremont & Fostoria Electric Railway Company, has presented each of the 23 employes of the road with a paid-up accident policy, good for $7.50 per week in event of injury, and $1,500 in case of death. The working day has been reduced to 10 hours.

PITTSBURG, PA.—The Pittsburg newspapers have started a movement for the establishment of a street railway men's relief fund by inviting the public to give the conductor on Monday, Dec. 24, some trifling sum, in addition to the regular fare of a nickel, and the sum thus realized is to form the nucleus for that fund.

KANSAS CITY, MO.—Articles of incorporation have been issued to the Kansas City & St. Joseph Railroad Company, capital $1,500,000, to operate an electric line between the two cities. The incorporators are Senator Perry A. Gibson and John Doll, Erie, Pa.; R. P. McGeehan, Homer Reed and C. E. Gibson, of Kansas City.

SCRANTON, PA.—The strike of the employees of the Scranton Street Railway Company, which began about ten days ago, was settled on Dec. 30, by a compromise between the strikers and the company. Several acts of violence took place during the strike, during which property of the company was damaged. The men get a ten-hour day at $1.85 per day.

AUSTIN, TEX.—The Sherman & Denison Electric Railway Company, which proposes to construct and operate an electric railway between Denison and Sherman, Texas, recently made application to the Railroad Commission of Texas for authority to issue $300,000 of first mortgage bonds, the proceeds of the same to be used in the construction of the road. The authority was granted.

JUAREZ, MEX.—The municipal authorities of this city are anxious to secure an electric street car service. They have offered the company operating the mule street car line exemption from all municipal taxation for a period of five years, and also to refund to the company over $15,000 of taxes that have already been paid if it will equip the cars with electric power. The proposition is being considered by the company and will probably be accepted.

GREENFIELD, IND.—The Indiana Railroad Company has been incorporated with a capital of $100,000 to build two inter-urban electric roads. One will be from this city to Knightstown, a distance of 14 miles, and the other from this city to Pendleton, a distance of 16 miles. The directors of the new company are all Greenfield men, namely: F. G. Banker, M. C. Binford, C. M. Kirkpatrick, E. J. Binford, W. C. Dudding, L. E. McDonald and W. R. McCowan.

PITTSBURG, PA.—The formation of the Union Traction Company, which means the consolidation of all the street car companies in this city, is now about completed. For a long time the matter has been hanging fire on account of litigation, but all legal entanglements were discontinued last Monday, when the different suits were compromised. This consolidation will take in the Consolidated Traction Company, the United Traction Company, the West End Traction Company, the Suburban Traction Company and the Monongahela Traction Company.

BLACK RIVER, N. Y.—The consolidation of the Black River Traction Company with the Dexter & Brownville Street Railway Company has just been certified to the Secretary of State of New York. Their capital stock is $65,000 and $40,000 respectively. The name of the new corporation resulting from the consolidation is the Black River Traction Company. The capital stock is $105,000, divided into 1050 shares of $100 each. The directors are Julius A. Lebknecher, George Krementz, Chandler W. Ricker of Newark, N. J., and Hiram F. Inglehart, George H. Walker, Thomas Burns, N. P. Wardwell, Chester C. Inglehart and S. R. Smith of Watertown.

THE MINNEAPOLIS STREET RAILWAY lines were tied up in rather a remarkable way recently. The dam which furnishes power to the street cars lies a short distance below the dam used by the flour mills. In consequence of the shutting of the mills the water was held back and the street railway water wheels soon exhausted the supply of water in the fore bay. The railway company, realizing that it would take some time for the water to rise sufficiently to turn the water wheels, ordered its local steam power houses started. However, it takes considerable time to get the steam power under way, and by the time that everything was in readiness the water had risen and was rushing over the dam at its usual rate.

CONNECTICUT.—As a result of projected trolley parallels between Waterbury and Middletown, New Haven will change the Waterbury, Meriden & Middletown road, about 26 miles long, between Waterbury and Middletown, to an electric line. It is understood that the opposition of the New York, New Haven & Hartford Railroad to the acquisition by the United Gas Improvement Company of trolley lines in Connecticut will only temporarily set back the plans of the latter company. The New Haven Company attempted to prevent the United Gas Improvement Company from securing control of a trolley line between Bridgeport and New Haven and won in the courts. Meantime, however, an entrance into New Haven was secured by way of Derby, so that connection by trolley between New York and New Haven is complete.

NIAGARA FALLS, N. Y.—At a meeting of the boards of directors of the Niagara Gorge Railroad and the Niagara Falls Street Railway, held in Buffalo, General Francis V. Green, of New York, tendered his resignation as president of the companies represented, and Captain Joseph T. Jones, of Buffalo, was elected to succeed him. It is understood that Captain Jones will give considerable attention to the roads of which he is the head, and it is understood that the line of the Niagara Falls Railway Company will be constructed under his management. This new line will give the Niagara Gorge Railroad direct connection with Prospect Park by way of Main, Falls and Riverway streets. At present the Niagara Gorge road uses the tracks of the Niagara Falls & Suspension Bridge Street Railway Company from Second street to the monument at the foot of Falls street. It is evident from the influence and energy of Captain Jones that the travel over the Niagara Gorge Railroad during the Pan-American year, and all future time, is to be well looked after.

THE AUTOMOBILE.

INDIANAPOLIS, IND.—An effort is being made to organize an automobile club in this city.

THE AUTOMOBILE CITY.—The Junior Munsey for January contains an article on Washington, as the automobile city. It shows eleven illustrations of vehicles, of which nine are Columbias.

AUTOMOBILES IN WASHINGTON.—Bills are before Congress for the appropriation of money for the purchase of electric vehicles for delivering books from the Congressional Library to senators and members of congress at their homes, and also for electric vehicles for police ambulances and patrol wagons.

ELIZABETHPORT, N. J.—The Riker Motor Vehicle Works at Elizabethport was partly destroyed by fire on Dec. 29. The fire started in the boiler room, and spread through the west wing, including the machine shop, engine room and trimming department. Several unfinished automobiles were burned and a large lot of material.

AN AUTOMOBILE STAGE LINE will be operated between Columbus, Ind., and Bloomington, via Nashville. Two three-seated machines are being built on a guarantee that they will make the trip between the two places in four hours, a distance of 40 miles over the most hilly region of the State. Each machine will carry six passengers and baggage. The fare will be 3 cents a mile.

AUTOMOBILE CLUB OF AMERICA.—The committee on new quarters of the Automobile Club, composed of Albert R. Shattuck and Albert C. Bostwick, has about concluded arrangements for leasing rooms on Fifth Avenue, near the Plaza. A large automobile company will open storage and warerooms at the corner of Fifty-eighth Street and Lexington Avenue, where club members and visitors may store their machines. The club's idea is to have an attendant during the active season on the sidewalk to watch vehicles until men from the storage place can be sent to take them to the warerooms. The automobile company will send the carriages back at the call of the members. This does away with the necessity of the club's doing its own storing, cleaning and repairing, to do all of which successfully would require a building, paraphernalia, force of mechanics and superintendent that in nine times out of time would financially swamp any concern except one maintaining itself on strictly business principles—a thing that clubs rarely do.

NEW INDUSTRIAL COMPANIES.

THE CLARKE ELECTRO COMPANY has been incorporated in Delaware. It will make and deal in medical electrical appliances.

THE JOHN S. BUSHNELL COMPANY, of New York City, has been incorporated to manufacture electrical and steam appliances; capital, $25,000. Directors: A. C. Lippincott, of Newark, N. J., and J. H. Spencer and H. A. Hartt, of New York City.

THE ELECTRO-PNEUMATIC COMPANY, capital $1,000,000, has filed a petition of incorporation in Hartford, Conn. It is planned to build a pneumatic tube service between Boston and New York by which a package can be sent between these two cities in 27 minutes. The incorporators are Charles P. Phillips, Warren K. Dowe, James L. Wolcott, Charles B. Johnson, William C. Case and Percy S. Bryant, all of New York, except the last two.

THE CALAVERAS DITCH COMPANY, capital $2,000,000, has been incorporated in New Jersey to supply water for agricultural, mining and manufacturing purposes, and to construct reservoirs, dams, canals and pipe lines, and restoring and conveying the same. Of the capital stock $300,000 is to be preferred with 7 per cent. cumulative dividends. The incorporators: Alvah Beech Thompson, August Roesler and William Stone Hubbell, Jr., all of Jersey City.

TO BUY AND SELL STREET CAR TICKETS.—Articles of incorporation were filed by the American Co-operative Ticket Company, of Newark, N. J., the object being to purchase and sell street-car tickets, merchandise, real estate mortgages, hold and improve, lease and convey lands and real estate and personal property; also to deal in merchandise in the State of New Jersey and any other State or Territory of the United States. The capital stock authorized is $100,000. The incorporators are Franz J. Beyer, John S. Johnson and Charles G. Beyer, all of Newark.

LEGAL.

ELECTROLYSIS BY RAILWAY RETURN CURRENTS.—Judge Carter, of the Indianapolis Superior Court, has made a ruling holding the complaint sufficient in the case of the Manufacturers Gas Company vs. The Indianapolis Street Railway Company, for $50,000 damages for injuries to the gas company's pipes through electrolysis. The ruling is one of the first in the country on the question of whether or not damages will lie from injuries attributed to electrolysis. A judgment will next likely be given for the extent of the damages proven, and an appeal will likely be taken to the Supreme Court.

PERSONAL.

MR. W. J. HAMMER, who went over to Europe early in the summer to attend the joint Institute meetings and the International Electrical Congress, returned just in time for Christmas, having made a very thorough tour of the Continent, England, etc.

DR. T. C. MENDENHALL, president of Worcester Polytechnic Institute for seven years, has resigned, to take effect July 1, 1901, and his resignation has been accepted by the trustees. Poor health is given as the cause of his decision. Dr. Mendenhall, before going to Worcester, was superintendent of the United States Coast and Geodetic Survey at Washington.

MR. C. W. PRICE, the veteran telegrapher and electrician, who has of late been actively connected with the Montauk Multiphase cable, is once more among his friends after a very severe bout of illness, which threatened serious results at one time, but which seems to have left him better than ever. He has been using some of this enforced leisure to work out a new plan of electrical work, to which attention will shortly be called.

MR. GEORGE O. PROCTOR, of the Anchor Electric Company, Boston, has just received a very handsome compliment on retiring from office as Mayor of Somerville, Mass., after two years' incumbency. To him and his successor a banquet was given at Young's Hotel, Boston, on Dec. 28. The references to his administration were most flattering. and Mayor Proctor, in his acknowledgment, was able to point out the various ways in which he had conducted the affairs of the city on business principles with success and efficiency.

MR. CHARLES H. SCHUM, who has been with Messrs. F. A. La Roche & Co., of New York, for the past four years, has resigned his position as electrical engineer to accept one with the Bergmann Electromotoren und Dynamo Werke, of Berlin, Germany. Mr. Schum is a graduate of Sibley College, Cornell University, class of 1895, and has had an extensive experience in switchboard and dynamo practice. Mr. Schum will sail from New York for Germany on Jan. 3.

OSTERBERG & SUTTON.—The well-known consulting engineering firm of Osterberg & Sutton, 11 Broadway, New York, dissolved on Jan. 1. The two members of the firm will continue their engineering practice separately at the same address. Mr. Max Osterberg, E. E., A. M., will continue to devote himself to consulting engineering and expert work. Mr. Frank Sutton, E. E., will continue work along the same lines, and is prepared to draw up specifications for heating and ventilating plants and sprinkler and fire protection systems.

Trade Notes.

THE WESTERN ELECTRIC COMPANY, Chicago, is prepared to furnish arc-light carbons for direct and alternating current lamps. It would like to receive specifications.

THE AMERICAN ELECTRICAL WORKS have issued as the illustration of their calendar for 1901 a picture of Michael Faraday together with a commendation of Faraday's work by Tyndall.

THE HAINES & NOYES COMPANY, of Chicago, Ill., has just closed a contract for equipping with telephones the traffic and advertising department of the Chicago & Great Western Railroad, Chicago.

FOOTE, PIERSON & CO., 82 and 84 Fulton street, New York City, have issued to their friends a neat little vest pocket book with calendar, and containing a large amount of useful information. It is bound in a prety celluloid cover.

THE AJAX IRON & WIRE COMPANY, of Brooklyn Borough, New York, has been incorporated with a capital stock of $5,000. The directors are Lina Beecher and M. L. Smith, of Brooklyn, and Banyon Moore, of New York City.

TEXAS ARM & PIN COMPANY, of Beaumont, Tex., has distributed among its friends and patrons as a New Year memento a very tasteful and substantial leather pocketbook, which all who receive will be very glad to carry around with them.

THE JEFFREY MANUFACTURING COMPANY, Columbus, Ohio, has issued a 96-page catalogue (No. 57) for the sawmills, lumber and woodworking industries. A copy of the catalogue, which is profusely illustrated, will be mailed to any one interested in the subjects.

THE MAXWELL M. MAYER ELECTRIC COMPANY, 2369 Second avenue, New York, has issued Bulletin No. 9, dated January, 1901, in which are described the direct-current dynamos and motors built by this concern. These machines have been on the market for six years.

AMERICAN ELECTRIC TELEPHONE COMPANY, 38 to 50 West Jackson Boulevard, Chicago, has issued to its friends and patrons a very neat little model telephone receiver, of the butter stamp pattern. It is about an inch in length and makes a neat watch charm.

CHARLES J. BOGUE, 209 Centre street, New York, reports sales as being very good at present, and the demand for his automatic focusing lamps exceedingly large. A special feature of these lamps is that a saving of over 40 per cent in current is effected by using two lamps in series.

ELECTRICAL CONDUCTORS.—The American Steel & Wire Company has issued a "pony" catalogue and price list of electrical conductors of all sizes and for all uses. It will be followed later by a more elaborate production. Copies of the booklet may be obtained by addressing the company at any of its sales offices.

AMERICAN BRIDGE COMPANY publish some interesting views of the famous Atbara bridge in Egypt, built at their Pencoyd Works in record time. One point in connection with that "mish job" was the fact that electric motors are freely used at Pencoyd, contributing greatly to speed in production of finished product.

THE ST. LOUIS AUTOMOBILE & SUPPLY COMPANY, St. Louis, Mo., is sending out a batch of circulars of interest to automobilists. This company carries a full line of automobile supplies, and complete vehicles of the gasoline type. It also makes electric vehicles, and has some second-hand machines on hand, which are stated to be in perfect condition.

ENGINEERING FIRM.—Messrs. N. S. Amstutz and H. C. Osborn announce that they are associated under the name of Amstutz-Osborn Company, and will carry on business as designers, supervisors and contractors of special mechanical and electrical devices. The company will also solicit United States and foreign patents. Its headquarters are in the Caxton Building, Cleveland.

THE WARD LEONARD ELECTRIC COMPANY, Bronxville, N. Y., states that the year 1900 was the most successful it ever had, and that 1901 has every promise of being better. The company states that its exhibit at the Paris Exposition and the fact that it secured the only gold medal awarded in its line of goods, have resulted in a splendid increase in its foreign trade all over the world.

AUTOMOBILE BATTERY.—Messrs. Sipe & Sigler, Cleveland, Ohio, manufacturers of the Willard storage battery, are preparing to bring out a new battery for automobile work. It shows a slight change in construction over the present battery, and it is claimed that the liability to short circuit is lessened, that the life of the battery is increased, and that a more uniform voltage is obtained.

MR. W. F. WENDT, president of the Buffalo Forge Company, Buffalo, N. Y., has called a meeting of its various representatives to be held in Buffalo the first week in January to discuss business prospects for the coming year. This enterprising company offers several prizes for the best suggestions at this meeting by the representatives as to how best to increase business and promote the interests of the company.

THE ELECTROLYSIS PROOF CONDUIT MANUFACTURING COMPANY, Chicago, whose factory was destroyed by fire recently, resumed its work on Jan. 4 in larger quarters with a capacity three times what it possessed before. Its present contracts cover about 600,000 feet of conduit, and notwithstanding the loss by fire the company has declared its first quarter's dividend of 2½ per cent. on a capitalization of $150,000.

THE TRIUMPH ELECTRIC COMPANY, Cincinnati, Ohio, has just furnished dynamos to the city of Dayton, Ohio. A shipment of generators and dynamos has just been made to the State Normal School at Peru, Neb.; another to the Silvertown Mining Company at Silvertown, Col. The company is also wiring two boats for the Convoy Towboat Company. The Triumph Company has secured the contract for the machinery to be installed in the municipal plant at Versailles, Ohio.

THE NEW YORK SAFETY STEAM POWER COMPANY, 113 Liberty street, New York, in a recent catalogue, describes the features of the Worthington boiler. The advantages possessed by this boiler are accessibility to its parts, and consequent ease of repair; absence of brick work, and straight tubes without screwed joints, gaskets or leaks. Every one interested in steam boilers will no doubt find much of interest in the construction of this one. A copy of the catalogue can be had by asking for it.

MECHANICAL STOKERS.—A very artistically gotten-up catalogue, with many excellent illustrations, has been issued by the Westinghouse Machine Company, in which is given some valuable information about mechanical stokers. The new Roney mechanical stoker is manufactured by this company, and is the subject of the catalogue. Its operation and application to boilers of all types are clearly illustrated. The advantages of the use of this type of stoker are pointed out, and a list is given of the concerns using it.

THE KEYSTONE ELECTRICAL INSTRUMENT COMPANY, Philadelphia, has placed in New York a very complete stock of its indicating instruments. A portion of this stock will be on exhibition at the company's office, No. 15 Cortlandt street, the balance being held in the storeroom, boxed and packed ready for delivery. The rapid increase in its business from New York City has rendered it advisable to carry such a stock, in order that the company may meet demands for prompt deliveries in cases of emergency.

THE BUCKEYE ELECTRIC REPAIR WORKS, Columbus, Ohio, are experiencing remarkable business. They have had to extend their plant and are running over-time. These are the only electric repair works in Columbus. They are owned and operated by Messrs. E. F. Coldren and A. F. Beck, under whose able management the most careful work is done in the way of building and repairing all classes of electric power generators and motors, refilling commutators, etc. The company is also in a position to estimate upon and install complete isolated plants.

POWER PRESSES.—Messrs. G. A. Crosby & Co., 2836 Archer avenue, Chicago, Ill., own and operate the plant of the E. S. Stiles Press Company, formerly of Watertown, N. Y. Messrs. Crosby & Co. have issued a four-page sheet, enclosed in a large mailing envelope, describing and illustrating their new plant, which is operated entirely by electric power. The generators, switchboards, motors, etc., were built and installed by the Northern Electrical Manufacturing Company, Madison, Wis. The Crosby Company manufactures foot and power presses, shears, etc.

THE STEPHENSON MANUFACTURING COMPANY, Albany, N. Y., is sending testing samples of its bar belt dressing by mail, free of charge, to all who are interested in maintaining full speed with the least trouble, and with the least expense. In the use of this dressing a clean power station is guaranteed by the makers, as it is applied to the belt by friction and consequently stays where it is put—on the belt. No spattering of floor, side walls or ceiling. Duplicate orders from those who have used nothing else for ten years speak well for its belt-preserving qualities.

STANLEY ELECTRIC MANUFACTURING COMPANY, Pittsfield, Mass., are pushing their S. K. C. hot wire ammeters and voltmeters, to which attention was recently directed by an article in these pages. They recommend particularly their hot wire portable ammeter, which is mounted in a well-finished, polished oak case, provided with lock and key. It is very light. Portable ammeters of 200 amp. or less, provided with only one range, have the shunt in the instrument case. Those for more than one range have the necessary shunts mounted in a polished oak box with connection leads.

HUBBARD, HALL & CO.—One of the noteworthy successes of the past year in the electrical supply business has been made by the firm of Hubbard, Hall & Co., of Cincinnati. They entered the field in November of 1899, and in six months were compelled by growing business to move into larger quarters at their present location, 213 West Fourth street. They have a new and large stock of all the standard and up-to-date supplies, and are ready to fill all orders right out of stock and make prompt shipments. They not only deal in electrical goods, but carry a line of mechanical supplies for factories, mills, etc.

COLUMBIA UNIVERSITY, New York, has recently announced that students desiring it can now take a course in motor vehicle construction. In adding such a course the faculty say that the motor vehicle has now become such a factor in commercial and private use that it is deemed as essential that a mechanical engineer should now be as well posted in motor vehicle construction as in marine, stationary or locomotive engineering. Sometime ago the International Correspondence Schools, Scranton, Pa., announced a course in gas, gasoline and oil engines in which special attention is given to the application of these engines to motor vehicles.

GENERAL ELECTRIC LITERATURE.—From the press of the General Electric Company has been turned out an artistic pamphlet of 42 pages, entitled "Type H Transformers in Use." The experience of central station managers using these transformers is given in fac simile reproductions of the original letters, and all speak well of the apparatus. The company has also issued Bulletin No. 4238, relating to railway motor controllers. The various types of controllers are illustrated, and their principal features pointed out. Price lists of "Red Core" and "White Core" wires and cables and a leaflet on an improved arc for series incandescent street lamps have also been issued.

MESSRS. CHARLES H. BESLY & CO., 10 North Canal street, Chicago, Ill., are receiving many inquiries for their catalogue, together with requests for estimates on tools and material. Many letters are being received from foreign countries, asking for circular matter and full particulars regarding their specialties and recent shipments of same have been made to Buenos Ayres, Montivideo, Brazil and England. They report that they are very busy at their factory, and by the addition of new and special machinery, they have increased their output five fold. Their new 300-page illustrated catalogue is now ready for distribution, and will be mailed to any address free upon application.

THE B. F. STURTEVANT COMPANY, of Boston, Mass., was recently in receipt of a letter from the Enterprise Foundry Company, of Sackville, N. B., which contained this interesting evidence of the endurance of one of their blowers: "We have had one of your No. 6 noiseless blowers in use for 28 years with entire satisfaction, but the blast wheel is now apparently worn out, and the left side piece is broken. If we had this left side piece and the blast wheel as shown in your circular it would make the blower all right. Can you furnish this for the No. 6 blower which you were selling in 1872? This blower is driven by two belts, but we fear we have been driving it at too high a speed."

NEW AGENCY.—The American Electric Fuse Company, Chicago, announces that it has secured the general Western agency of the McIntire Company, of Newark, N. J. It will also handle American and improved American connectors, as well as a full line of fuses, fuse blocks, lightning arresters, paper insulators, magnet wire and other electrical specialties. The company will mail a catalogue, or send samples free to any one desiring them. It also announces that it has been appointed general agent for the sale of A. B. C. battery compound, which is a substitute for sal ammoniac. Many important advantages are claimed for this compound. Those interested in battery work will do well to investigate its merits.

CALENDARS.—The Rollins Engine Company, Nashua, N. H., has issued an art calendar containing a reproduction of Detti's painting, "A Minister of the Old School." The coloring is well done, and the calendar presents a tasteful appearance. The Emerson Electric Manufacturing Company has issued a desk pad calendar for daily memoranda. The space for notes is entirely ample, and is, in fact, a little larger than is usually given to such calendars. Throughout the calendar is advertising of the Emerson specialties, and on the back of the pad is a complete calendar for 1902. The Direct United States Cable Company has issued a neat 1901 calendar showing the sprite electricity joining the hands of Columbia and Britannia.

A NOVEL SUBWAY STATION.—Underneath the Germania Theatre property, purchased by John Wanamaker, the New York Rapid Transit Commission had designed to place a station of the rapid transit subway; and the acquisition of the property by Mr. Wanamaker will not cause any change in the Commission's plan. It will be necessary for the city to condemn only the basement of the property; all above that may remain Mr. Wanamaker's. Hence, if Mr. Wanamaker should extend his store over his recent acquisitions of property on Fourth avenue, Eighth and Ninth streets, as his intention apparently is, he would have one of the most important stations of the trunk line portion of the subway directly in his own basement. Mr. Wanamaker is credited with contemplating a larger project than the extension of his store to cover the Fourth avenue end of the block bounded by that avenue, Eighth and Ninth streets, and Broadway. It is understood, upon good authority, that he is negotiating for the purchase of that entire block, with a view to erecting upon it a store building to eclipse all rival structures of the kind.

THE VIADUCT MANUFACTURING COMPANY and its predecessors have been advertisers in THE ELECTRICAL WORLD AND ENGINEER and its predecessors since the *Operator* was first issued 27 years ago, which is substantial evidence of the WORLD'S value as an advertising medium, and it also shows the long-continued work of the Viaduct Company. Another good word for the stability of this company is that it still has several employees in the service who began with Mr. Augustus G. Davis, the president, in January, 1871. Mr. Davis has been identified with the company as its head since that date. During this time it has continuously made district messenger boxes and supplies. When the telephone was invented, the company contracted with the American Bell Telephone Company to manufacture for it during a period of five years, since which time it has been actively engaged in manufacturing telephone instruments, as well as district telegraph messenger boxes and supplies. Its immense factory is located at Relay Station, B. & O. R. R., which is run by water power from the Patapsco River, where the great viaduct, from which the company derives its name, crosses the river. This viaduct was built in 1834, and was first of its kind constructed for railroad purposes in the United States. This company has a long line of specialties of modern styles, many of which are familiar through their illustration in these columns.

THE VICTOR ELECTRIC COMPANY (incorporated), 418 Dearborn street, Chicago, Ill., carries over from the old century to the new a large and varied business, together with a large stock of practical experience that promises to forward the concern to greater successes than it has ever before enjoyed. The chief business of this company is the manufacture of dynamos and motors of capacities under 1 h.p., rotary transformers, electric air compressors, electric lathes and other small direct-connected apparatus. These limits include a great variety of apparatus and instruments that is best shown by the voluminous trade literature of the company. Among its specialties are high-grade dental and surgical instruments, including, besides the motors, batteries, rheo-

stats, induction coils, electric dental engines, shunt boxes, and the great variety of devices that go toward making dental and surgical outfits complete. The electric motor is a very compact machine, iron-clad and entirely protected against injury from outside causes. In the ¼-hp. size the starting and regulating rheostat may be located on top of the motor, if so desired. The direct-current rotary transformer has, in the largest size made by this company, a capacity of 60 amperes at 6 volts, the transformation being from 4 amperes at 110-volts pressure. The machines can, however, be wound for 220 volts if desired. They also are entirely iron clad. All those operating gas and gasoline engines will be interested to know that the Victor Company manufactures an efficient igniter. All the switching is done automatically, and the cost and care of batteries are reduced to a minimum by the use of this machine.

Record of Electrical Patents.

663,951. SYSTEM OF MOTOR CONTROL; Abert H. Armstrong, of Schenectady, N. Y. App. filed Oct. 6, 1900. A multiple control system for induction motor railway car equipments. A master controller controls a plurality of small induction motors on each car, the latter in turn actuating contact devices.

663,981. ELECTRIC LIGHTING APPLIANCE; Arthur Peters, of Manitou, Col. App. filed Nov. 11, 1899. A magnetic cut-out which is tripped when an excess of current passes through a relay electromagnet.

664,369. TELEGRAPHY; W. E. Athearn, New York, N. Y. App. filed April 5, 1900. Static discharges from condensers instead of induction impulses from induction coils, are employed to produce a more perfect method of dual transmission than has heretofore been attained.

664,371. ELECTRIC HEATER AND CIRCUIT CONTROLLER THEREFOR; J. I. Ayer, Malden, Mass. App. filed May 20, 1899. A circuit closer is attached to the oven in such a way that the act of placing anything in the oven necessarily closes the circuit.

664,396. DYNAMO ELECTRIC MACHINE; I. Fisher, Boston, Mass. App. filed April 3, 1899. The commutator has a segment for each armature coil, the alternate segments being connected with each other and adjacent segments being connected respectively with the opposite ends of the series winding on the armature poles.

664,430. TELAUTOGRAPH OR FAC SIMILE TELEGRAPH; A. Pollak, Budapesth, Austria-Hungary. App. filed Dec. 21, 1899. Comprises improved means for moving the ray of light along the receiving chamber, said means being an improvement upon the device for a similar purpose described in a previous application.

664,432. INSULATOR; E. Renault, Waldo, Fla. App. filed May 8, 1900. A porcelain insulator made in two parts of peculiar shape and threaded together to clamp the wire between them.

664,442. COIL FOR ELECTROMAGNETS; S. D. Sprong, Long Branch, N. J. App. filed Nov. 29, 1899. To facilitate repairs the coil is wound in sections separated by rings of insulating material, so that any section can be removed and replaced without difficulty.

664,459. OVERHEAD ELECTRIC TROLLEY; J. H. Brown and W. H. Tobin, Jr., Pittsfield, Mass. App. filed July 10, 1900. One side of the harp is pivoted to the other side and held in operative position by a latch, so that it may be easily opened to remove the wheel.

664,470. CONSTRUCTION FOR THIRD-RAIL ELECTRIC RAILWAYS; W. Courtenay, New York, N. Y. App. filed Sept. 29, 1900. An insulator block upon which the third rail rests, having overhanging sides and means for attaching brackets to hold the rail.

664,503. COLLECTOR RING; H. G. Reist, Schenectady, N. Y. App. filed March 29, 1900. A current collector comprising a split collar or hub adapted to be mounted on a shaft, and a split contact ring provided with feet supported by said hub, but separated therefrom by insulated metallic clamps.

664,511. ELECTRIC CUT OUT; J. H. Trumbull and H. Trumbull, Hartford, Conn. App. filed April 17, 1899. Details.

664,550. ELECTROLYTIC TREATMENT OF IRON FOR PRESERVATION THEREOF; H. L. Hollis, Chicago, Ill. App. filed Feb. 20, 1899. The iron object is first made the cathode in a caustic soda solution to clean its surface, and is then made the anode in the same solution to oxidize its surface.

664,554. REGULATING SOCKET FOR MULTIFILAMENT INCANDESCENT ELECTRIC LAMPS; C. A. Hussey, New York, N. Y. App. filed Aug. 29, 1900. Details of a socket switch for throwing the several filaments into and out of circuit.

664,557. TELEGRAPH SWITCHBOARD; F. W. Jones, New York, N. Y. App. filed July 16, 1900. Two series of conducting strips are attached to the opposite sides of an insulating frame; one series contains large holes and the other small holes. A tapered plug having an insulated conducting end and a conducting sleeve will pass into said holes and fit, the one in the small hole and the other in the large hole.

664,594. MEANS FOR TRANSMITTING MOTION TO DISTANT POINTS; D. P. Thomson, Lynn, Mass. App. filed Sept. 29, 1900. By this invention it is possible to secure the simultaneous movement of any number of controller cylinders upon each movement of a master controller, and the stopping of the controller at the desired point without opening the controlled circuit between the actuating motor and the master controller.

664,649. BRUSH HOLDER FOR DYNAMO ELECTRIC MACHINES; C. W. Kragh, Madison, Wis. App. filed Sept. 11, 1899. A spring is secured at its free end to the brush for conducting purposes, while another spring furnishes the necessary force to hold the brush against the commutator.

664,650. ELECTROMAGNETIC ORE SEPARATOR; E. Kreuser, Mechernich, Germany. App. filed Sept. 2, 1898. The separator consists of two rotary cylindrical magnets placed side by side so that a field of force will be established between the adjacent heads of each magnet.

664,667. ELECTRIC PUSH BUTTON; T. A. Nathans, New York, N. Y. App. filed June 1, 1900. The device is so constructed that the circuit will be closed when the button is pushed or when an attempt is made to remove the cover plate.

664,679. ACCUMULATOR; L. Renaud, Paris, France. App. filed May 24, 1900. Details.

664,681. ELECTRIC CALL BOX; E. A. Salisbury, Chicago, Ill. App. filed July 24, 1900. Details.

664,691. TELEPHONE EXCHANGE SYSTEM; C. Timberlake, Indianapolis, Ind. App. filed Oct. 23, 1899. The system comprises suitable calling lines, a series of connecting circuits and a switching relay in each connecting circuit so that if the circuit is in use the relay connects a calling line with the switching relay of next connecting circuit in the series.

664,713. ELECTRIC ARC LAMP; R. E. Ball, New York, N. Y. App. filed Sept. 21, 1899. This is a double lamp in which the current is shifted from one set of carbons to the other by means of levers, one having greater leverage than the other, and an arrangement for transferring to the lever having the greater leverage, when the first carbon has been consumed, part of the weight sustained normally by the lever having the lesser leverage.

664,733. METHOD OF CONVERTING THE ENERGY OF ALTERNATING CURRENTS INTO EFFECTIVE MECHANICAL ENERGY; Rudolf Eickemeyer, of Yonkers, N. Y. App. filed Nov. 21, 1892. A single-phase alternating current commutator motor, with two magnetic circuits. The commutator has alternate dead bars and an auxiliary coil in proximity to the armature which opposes its self-inductive effect, the armature current flowing in this coil. The form of the field is such as to oppose a high magnetic resistance to the fluxes in the local magnetic circuits surrounding the armature conductors.

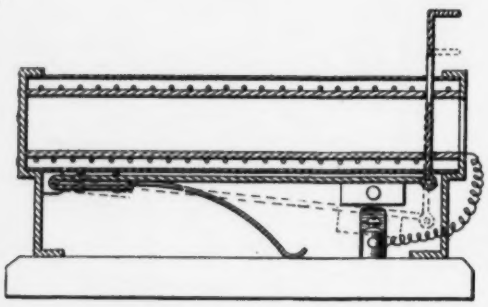
664,757. TELEPHONE SERVICE APPARATUS; U. S. Jackson, Ossipee, N. H. App. filed June 15, 1900. Details.

664,761. PRINTING TELEGRAPH; E. Kinsman, Malaga, N. J. App. filed Dec. 21, 1899. A type plate having four motions is shifted by suitable shift keys and the desired type then selected by the regular type keys, which are by this arrangement fewer in number.

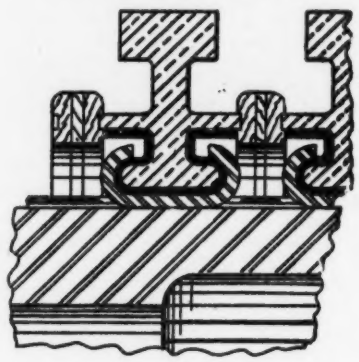
664,802. FIRE ALARM TELEGRAPH; L. G. Woolley, Kenton, Ohio. App. filed July 20, 1900. A motor and magneto electric generator are arranged to send an impulse over the circuits at intervals to indicate the condition of the lines.

664,807. ELECTRIC ADVERTISING DEVICE; P. Dawson, Detroit, Mich. App. filed May 24, 1899. Details.

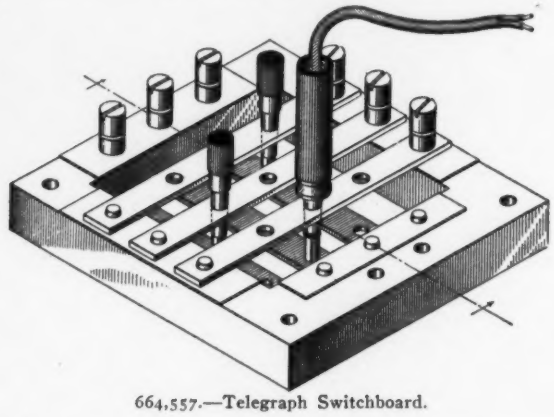
664,819. ELECTRIC SAFETY APPLIANCE FOR RAILROADS; E. L. Orcutt, Somerville, Mass. App. filed Jan. 3, 1898. Details.



664,371.—Electric Heater and Circuit Controller Therefor.



664,503.—Collector Ring.



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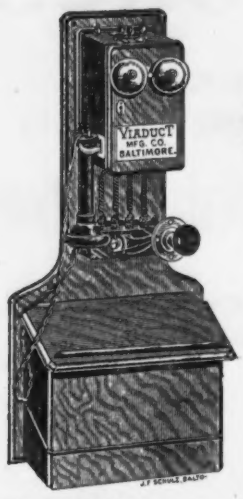

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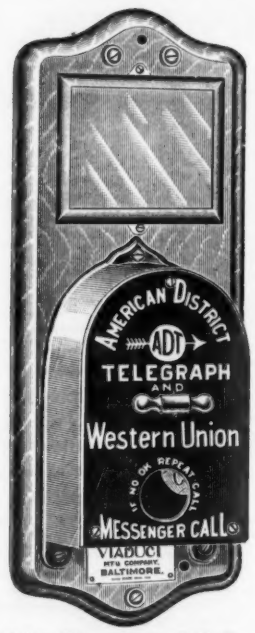

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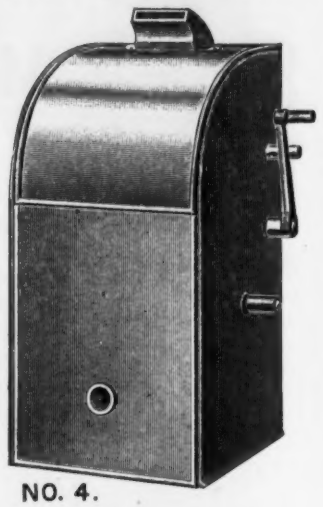
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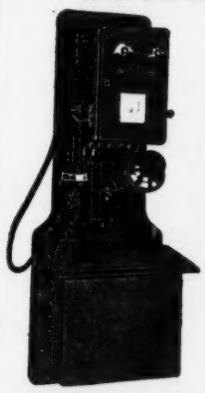

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Our system keeps accurate record of calls on a small register at the subscriber's station and each subscriber's register reading is taken by our portable record taker at the central office each month.

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1039 Marquette Building, Chicago, Ill.

FUSES, FUSE BLOCKS, TELEPHONE SUPPLIES.

American Electric Fuse Co.,
345 So. Canal St., Chicago, Ill.

The first and most important point about advertising is to select the right medium. If you want to do business with any man in the electrical field in any part of the world, the right medium to advertise in is ELECTRICAL WORLD AND ENGINEER.